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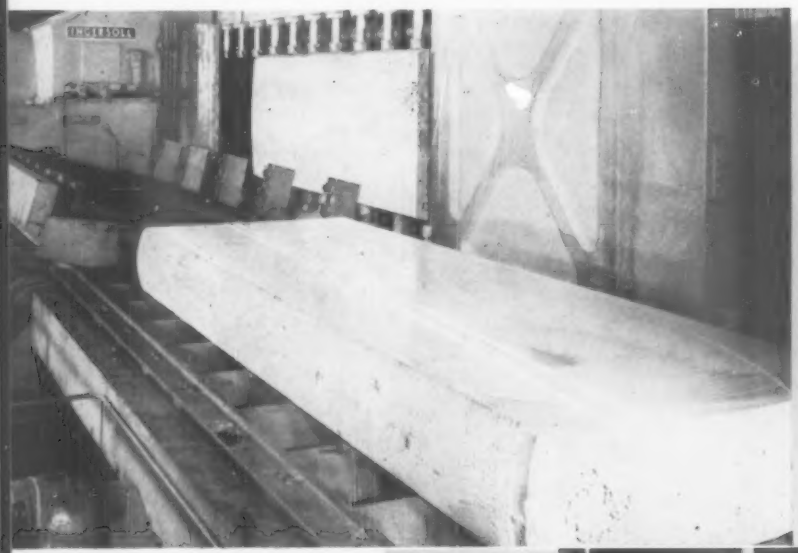
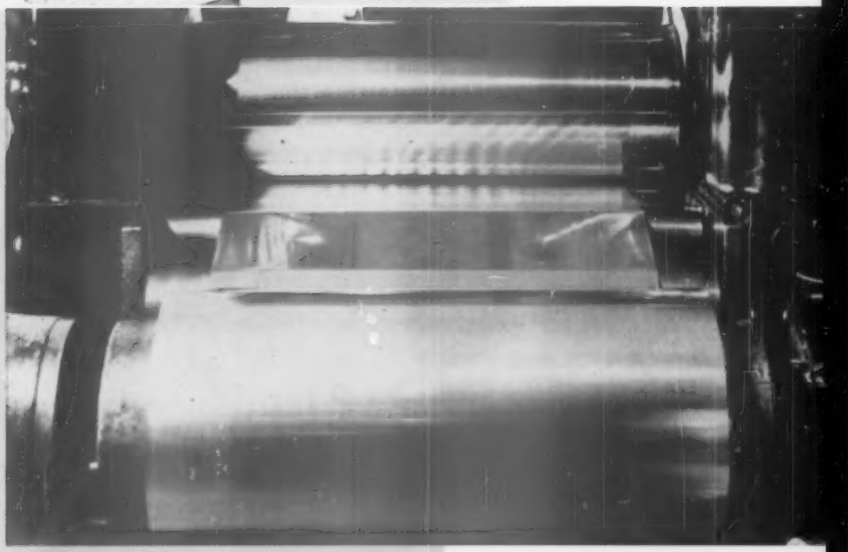
FT food technology





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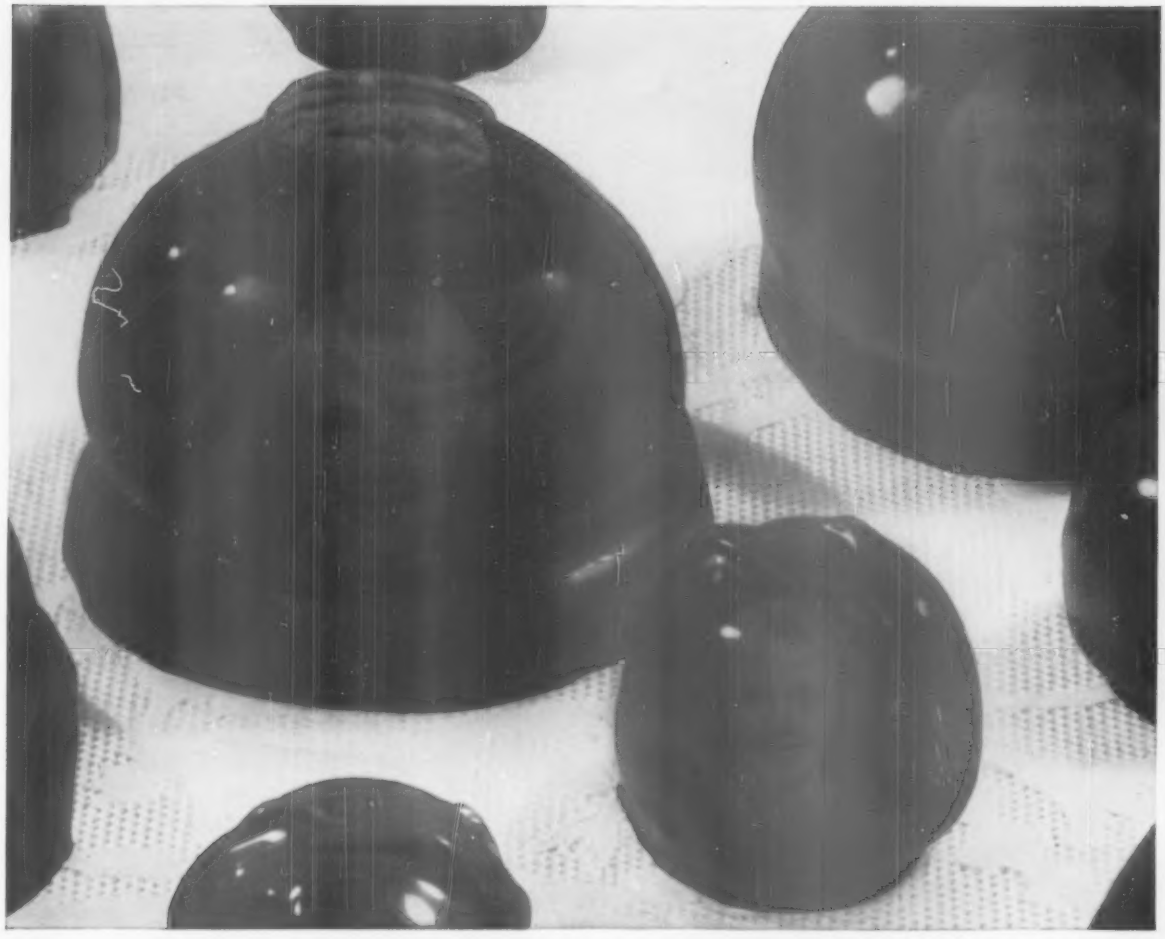

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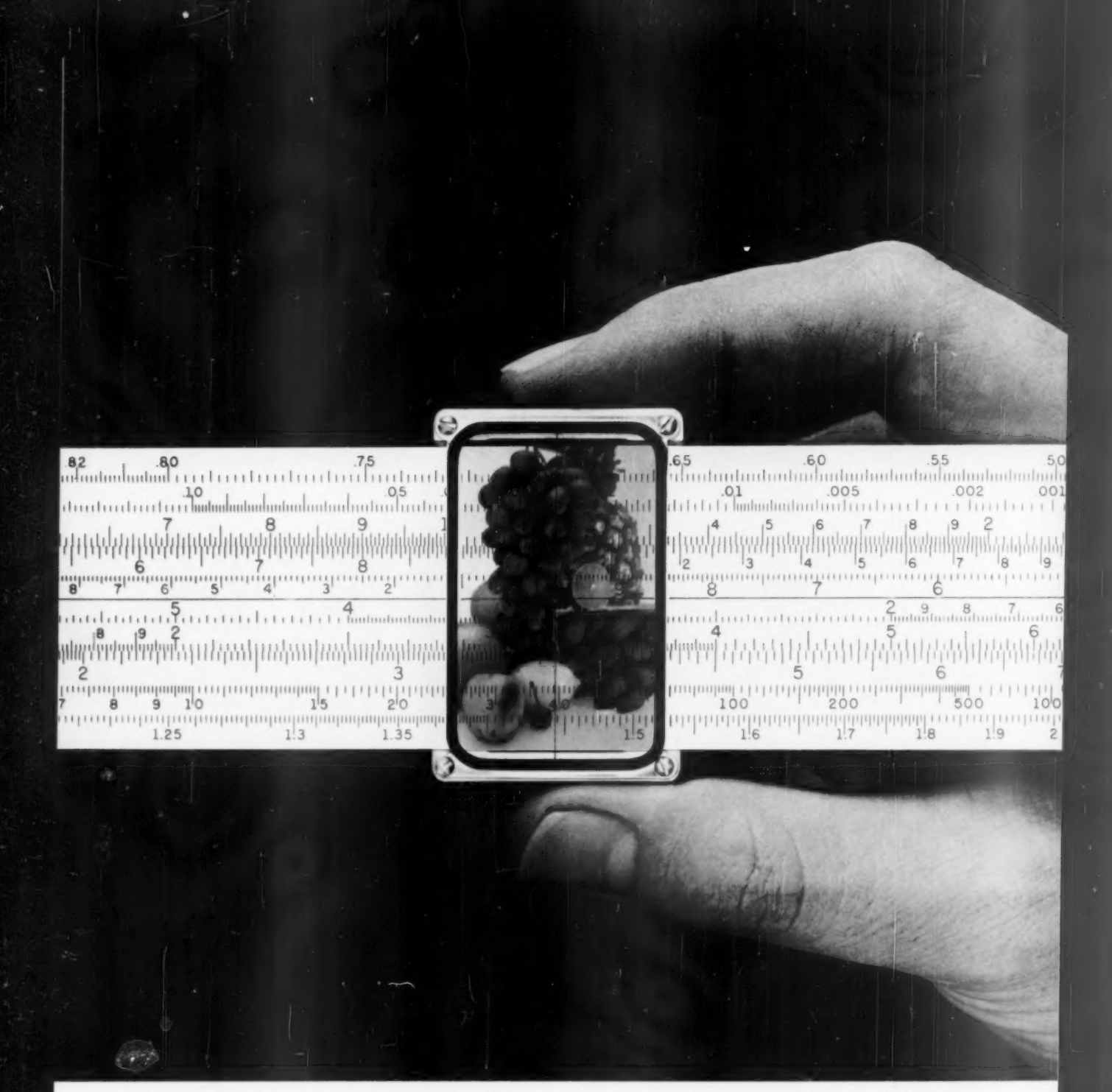

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FT food technology

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Obligations of Food Technologists to the Consumer*

J. B. Brown

Director, Institute of Nutrition and Food Technology and Chairman, Department of Physiological Chemistry, The Ohio State University, Columbus, Ohio

WHEN THIS SUBJECT was assigned to me by your program committee I was under the impression it would be easy to fulfill. Subsequently, however, it has seemed increasingly difficult.

J. B. Brown

The subject will be discussed from *two points* of *view:*

What the consumer expects from the food technologist.

The food technologist's obligation to the consumer.

Actually the *position of the food technologist in industry* may be a very *difficult one*. However conscientious he may be, he may ultimately be at the mercy of his company and especially of his sales organization. While the consumer may expect him to disparage misleading and extravagant claims for his products, he may be helpless.

WHAT THE CONSUMER EXPECTS

What does the consumer *expect* and *hope for* from the food technologist? In attempting to answer this question it seemed that any reply from a single person, such as myself, would be too narrow and perhaps too prejudiced. While I think I know what a food technologist is in a very broad sense, I'd certainly hate to be pinned down for a concise definition. In my mind a food technologist is an individual who has specialized in food technology in college in a suitable curriculum leading to a bachelor's degree and perhaps to the M.S. or Ph.D. degrees; hence, one who is scientifically trained, who knows about the chemistry of foods, and who knows what happens to foods during processing, etc. Often, however, the food technologist is one with specialized training in chemistry, or biochemistry, or horticulture, etc., who acquires food technology experience after he is on the job.

To answer the question therefore I sent out a letter to several of my colleagues, as follows: "I am writing this letter to a few of my more highly intelligent friends because this is an instance of 'when a feller needs a friend'. I have been assigned the topic 'What the Consumer Expects of the Food Technologist' at the February 26 meeting of the Ohio Valley Section of the Institute of Food Technologists. Can you disembody yourself from your professional attitude and write me a short note or sketch or outline of what you as a *consumer* expect from the food technologist?"

The answers came in. As mentioned, they were from my colleagues, professors at Ohio State University, and hence admittedly, perhaps, not a fair sample of the population. Some were members of the Institute of Food Technologists. I am not going into the replies in full detail, but some of the suggestions were well thought out. I am sure they should be considered carefully by you folks here in this audience in your capacity as food technologists.

One department chairman answers as follows: "I have your note of January 23 with reference to your talk before the Institute of Food Technologists. I asked my wife about what the consumer expects. I found immediately that she did not know what a *food technologist* is. What does he do? Is he a chemist only? Or does he concern himself with the gross aspects of foods? Does he have responsibility for analyzing for and discussing the importance of vitamins, etc., etc.? Even *I* had some difficulty in answering the questions in view of the wide activities and the range in number and type of people who call themselves food technologists. As a result, I was able to get little help from my wife. This may help to introduce the problem as I assume that others are as confused as she is and possibly *as I am*. There are *so many facets* in which so-called food technologists operate that the consumer is at a loss to know what to expect.

"But assuming that the food technologist is primarily concerned with the composition and nutritive value of foods utilized in human consumption, I would expect the food technologist to give *accurate, unbiased information, not influenced by any commercial industry* on such aspects of foods in their natural

July Cover. An early stage in the production of aluminum (upper photo), is a multi-ton ingot of aluminum, shown in a giant scalper at Reynolds Metals Companys' McCook, Illinois sheet and plate works. The ingot is next rolled into slab and thinned, in successive stages, into plate and sheet. Skilled craftsmen using machines like that in the lower photo can roll foil so thin that one pound will cover 70,000 square inches. From the foil mill the aluminum will go to one of Reynolds gravure plants where it may be laminated with other materials and printed in a wide variety of colors. Aluminum in one form or another is used in food packaging technology in the form of overwraps, innerwraps, pouches, labels, rigid containers and cans.

* Presented at the Winter Meeting of the Ohio Valley Section of IFT, February 26, 1960, Columbus, Ohio.

state as well as prepared and processed. To what extent should he concern himself with proper ratios of the various components of a meal is another question, but still important. To what extent does he concern himself with actual tests on rats, rabbits, guinea-pigs, or humans in supporting his conclusions?''

Another department chairman *who should know* makes the following suggestions:

''1. The consumer does not know what a food technologist is so your question should be what does the consumer expect in the food he or she purchases.

2. Wholesome food is a *must* but this is taken for granted.

3. It must be attractive in appeal and price.

4. It must be uniform and relatively high in quality.

5. The consumer will often take less in quality for the sake of uniformity and convenience.

6. The mass consumer is usually unwilling to pay the extra price for an epicurean delight, e.g., fancy cheese, prime beef, etc., etc.''

MUST KEEP FAITH WITH THE CONSUMER

A third department chairman expects the food technologist:

''1. To have full knowledge of the basic food problems which are exploited so generally in the daily press. In other words—the consumer is naturally concerned with such things as *contamination* with *pesticides, antibiotics, radioactive materials, dietary claims,* etc., and would expect the food technologist to deal with these problems objectively and intelligently.

2. Full knowledge of the physical and chemical nature of the food products which rightfully are included in his particular sphere of activity.

3. A clear understanding of the industrial processes which are involved in the processing foods in his area—and the ability to relate these industrial processes in a manner which will be understandable to the average consumer.

4. To be *fair* and *impartial* in the treatment of *consumers' questions* so as *not to destroy the consumers' faith* in *one food product while attempting to increase her confidence in another.*

5. To be honest enough to say 'I don't know' in cases where questions arise for which he does not have current information—rather than to give the consumer incorrect information which might, in the long term, be disastrous.''

A former department chairman and dean states:

''I am quite sure that what a consumer expects from a food technologist is something quite different from what a food industry or an educational or research institution would expect from a food technologist.

''It is my feeling that the consumer expects his or her foods to be of high quality and uniform in quality characteristics—such as appearance, taste, odor, etc. The consumer is interested in attractive and convenient-size packages and in ease of preparation for the table. I believe the consumer is also interested in

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new foods and by this I mean new preparations of the usual raw materials."

An associate professor and laboratory director (in consultation with his wife) makes the following points in connection with the consumer's expectations:

1. Wants more reusable containers.
2. Wants to see original colors of products preserved; wants containers to be transparent so that these colors may be visible.
3. Wants more emphasis on partially baked desserts, casseroles, and main dishes.
4. Wants methods devised to make such items as lettuce, celery, etc., table clean.
5. Wants a system of dating items to protect consumer against too long storage, or simply statement of packing date, etc.

This reply is from a home economics professor and a member of the Institute of Food Technologists:

1. Wants prepared foods as palatable as home processed.
2. Wants to be lured into wanting and trying new foods and food products.
3. Wants protection against unsafe foods.
4. Wants nutritive values safeguarded in processing.
5. Wants nutritive values enhanced where possible.
6. Wants prices kept reasonable.
7. Wants more convenience foods.
8. Wants food products made attractive.
9. Wants products with improved stability.
10. Wants more information on the package as to quality and standards.

My secretary who is a consumer with more information than most laymen wants in addition to the above, specific information on calorie values and contents of chief nutrients as proteins, individual vitamins, etc., on a per serving basis.

Final Comment: These are the expectations of a very select group of consumers. I am sure that the average layman knows very little about what a food technologist is, but he would still know enough to think of many of the points raised above by these more well-informed individuals.

WHAT ARE THE FOOD TECHNOLOGISTS' OBLIGATIONS TO THE CONSUMER?

The consumer, if he thinks, will expect the Food Technologist, first, to be well trained as a food technologist. Naturally, this raises the question: What training, then, should a food technologist have? This is a question with which the Curriculum Committee of our Institute of Nutrition and Food Technology on the campus has been concerned since 1946. We have been trying hard to answer this $64 question. Recently, the Education Committee of the Institute of Food Technologists has tried to answer the question. Generally speaking most of you will agree that your training should have included the following:

1. You must be well informed on the chemical composition of foods. This will involve courses in general chemistry, qualitative and quantitative analysis, organic chemistry and biochemistry.
2. You need to know a great deal about the physical properties of foods; hence, you should have had fundamental courses in physics.
3. Since foods are intended for nourishing the tissues of humans and animals, you should have a knowledge of biochemistry and nutrition,—biochemistry, the chemistry of the facts of life, and nutrition, how to make biochemistry possible. In food technology, these sciences supplement each other. Intermediary metabolism and nutrition are inseparable.
4. In addition to other courses in biological sciences, including bacteriology, botany, etc., you should have had training in many of the so-called broadening disciplines including the social sciences, English, etc., etc. Most of these are now required in the general curricula leading to the bachelor's degree.
5. Your training should, of course, have included some course or courses in Food Technology.
6. In order to carry on and direct research, a Ph.D. is surely required.
7. Chemical engineering, a 5 year program may be necessary.
8. You should continue to be *students at your work*, reading and learning more and more about foods and food processing, and the controls necessary for these operations.

These are your obligations to the consumer in the way of training.

YOUR OBLIGATIONS TO YOUR EMPLOYER AND THE PUBLIC

Now as to specific points of obligation, *as I see them*, which you owe both to your employer and to the public who will consume your products.

Naturally, you should have a *thorough knowledge* of the composition of the foods and food products which your company is processing for the public's use—learning all that is possible to learn by extensive reading and study. You are not likely to know *thoroughly* any given class of foods at the time of your graduation. Your knowledge must be vastly increased until in fact, you become an authority on these foods. You should know not only about the *proteins*, *fats*, and *carbohydrates*, which these foods contain, but you should be equally aware of the vitamins and the trace mineral elements which are so essential to nutritive values.

You should know the effects of processing on these products—the changes induced by heat and oxidation on protein, fat, and carbohydrates. Here particularly you should be aware that overheated and oxidatively rancid fats may produce toxic effects when consumed; also, such fats have reduced nutritive value. If you

are in an industry concerned with the hydrogenation of fats you should be aware of the profound chemical changes in fats induced by hydrogenation, not only the reduction in amounts of essential fatty acids but also the production of large amounts of other isomers of the unsaturated acids. The question of hydrogenation has been raised recently as to its possible deleterious effects in connection with the development of cardiovascular disease. You should be particularly aware of the effect of processing on the B vitamins. Some of these, particularly thiamine, are easily destroyed by heat so that it is impossible to process foods by heat without impairing thiamine content. In this connection you are up against the dilemma of destruction of B vitamin versus the loss of ascorbic acid, and you should make every attempt to preserve this essential nutrient. If a consumer expects ascorbic acid in it, he should not be disappointed. With reference to minerals you should continually keep in mind that most of these may be lost through leaching out in cooking water, and if these waters are discarded loss will result. In summary of this point, keep always in mind that overprocessing will usually be harmful.

You should always be aware that the nutritive values of your products will never exceed the nutritive values of the raw products as you receive them. In other words, you may have to look farther back than your receiving platform as to the history of the products as they come to you. Remember the consumer will depend upon you for products of maximum nutrient value.

4. You should be thoroughly acquainted with the science of nutrition which deals with the nutrients in foods and their metabolic functions. The conscientious food technologist must remember that the sole function of his products is to feed humans, or, in the animal feed industries, to feed livestock. Without man and animals you would have no job. In this connection it occurs to me to suggest that a knowledge of nutrition will involve more advanced study than any formal training you may have had in this subject. Do you know the major problems of protein nutrition as they affect the American people? Are you thoroughly informed of the functions of each vitamin and mineral, and what its loss in your product may do for some one? A good food technologist must, ideally, be a good nutritionist. This is one of your important obligations.

The most important problem before clinical medicine today is the problem of cardiovascular disease as typified by the fact that some 50 to 60 per cent of our people are dying from coronaries, the major cause of death. As one who has for a long time been interested in the biochemistry of fats and oils, I am unhappy to say that dietary fats are alleged to be one of the principal causes of atherosclerosis and coronary occlusion. While there are many controversial points to this story, I think the food technologist owes it to the consumer to be thoroughly aware of the background of this allegation. There is a strong point of view presently among the medical profession and among those working in this field that we are eating too

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much fat, and particularly too much of the saturated fats. Three or four principal delectations by which Americans are tempted by the food industries are salted peanuts, potato chips, french fries of all kinds, and buttered popcorn. I think increasingly in the future the food technologist will be called upon to develop new products of lower fat content from the raw materials which basically constitute the products just mentioned. In this direction, also, I think the food industries employing hydrogenation of fats should seriously consider use of products with less hydrogenation and a higher content of the original vegetable oils than the products now on the market. The dairy industry might well be advised that its emphasis on butterfat is being increasingly called into question. We may well be on the verge of a rather complete change in our attitudes toward dietary fats. The food technologist owes it to the consumer to be informed on these problems and to provide products of maximum nutrient value to the consumer.

The food technologist owes it to the consumer to wage his own private war towards discouraging misleading and extravagant claims. The consuming public is tired of unjustifiable superlatives. I am depressed by the fact that *all beers are claimed to be the best beer* which obviously is not true. One of the newer brands of margarine makes the claim that it is made entirely from corn oil, incidentally a fine food fat, but in the small print on the package is the statement that it is partially hydrogenated corn oil. No two fats can be so completely dissimilar as corn oil and partially hydrogenated corn oil. The hydrogenated fat is a new and synthetic fat, containing innumerable compounds not present in corn oil itself.

You, as a food technologist, should ever keep in mind the question of food additives. The consumer of your product expects you to provide a product containing no additive which is harmful.

You should be equally aware of the possibility of the presence of spray residues in the raw materials you receive and be willing by chemical analysis to guarantee freedom from toxic materials. Heaven help you, if you allow even the remotest traces of compounds in your products "which when fed to rats will cause cancer"!

The consumer expects of you, and I believe you are obliged to provide him from time to time with, new and attractive products. For example, the consumption of potatoes will be gradually increased as new and convenience forms of potatoes are available. The availability of thoroughly palatable powdered mashed potatoes is welcome. These are now good enough that even restaurants are beginning to use them. Food technologists in the dairy industry can well provide a reconstitutable condensed milk or whole milk powder, etc. The deep freeze and the convenience foods offer unlimited opportunity for creative work.

Last but not least the question of cleanliness in all plant operations is surely very important. Your consumer expects you to assure wholesome and clean food products.

These, then, are some of the obligations, in my opinion, of food technologists to consumers.

IN THIS ISSUE—

TECHNICAL ARTICLES IN BRIEF

Radiation of foods *Beef*

The thiobarbituric acid test in irradiation-sterilized beef. Norman L. Smith, Ian J. Tinsley, and E. C. Bubl.

Beef, irradiated with gamma rays gives an intense color reaction with thiobarbituric acid. The red color produced in this reaction has been shown to be due to the formation of two pigments with absorption maxima at 534 mmc and 552 mmc. The former corresponded to the pigment produced in the reaction of malonaldehyde with thiobarbituric acid and the latter corresponds to one of the pigments produced in the reaction of glyoxal with thiobarbituric acid. Some studies have been made of the nature of the color precursors in the irradiated beef. (See page 317).

Sensory evaluation *Monosodium glutamate*

Monosodium glutamate studies. I. Factors affecting detection of and preference for added glutamate in foods. Helen L. Hanson, Marian J. Brushway, and Hans Lineweaver.

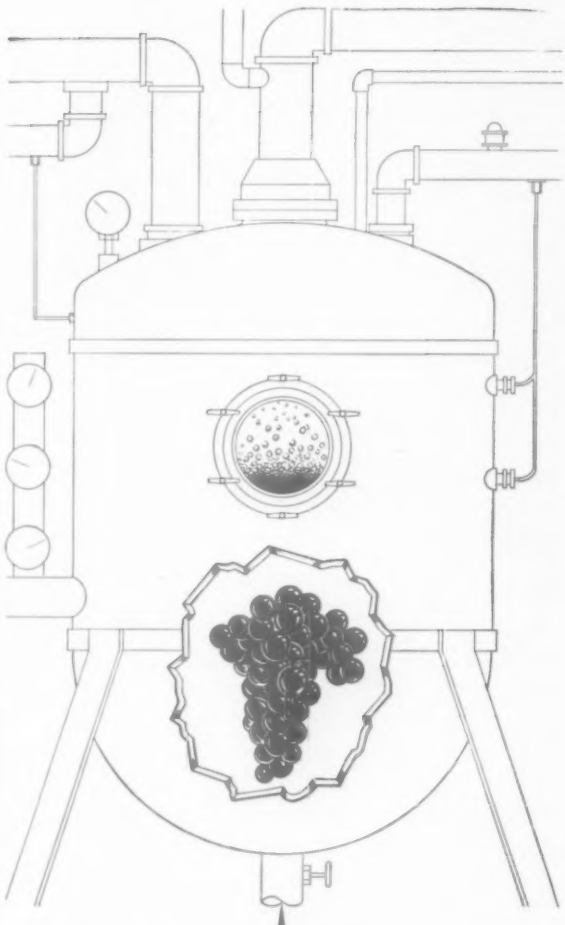
The glutamate ion has a specific flavor effect more readily detected than the chloride ion when NaCl and glutamate are added at approximately equal sodium concentrations to chicken broth containing normal amounts of NaCl. The panel selected for acuity to glutamate readily (95% of possible judgments) detected glutamate added to unseasoned chicken broth at levels ranging from 0.015 to 0.04%. Addition of thickenings, fat, and seasonings inter-

fered only slightly with detection of the above levels. Added glutamate was less readily detected in foods such as peas and liver paste than in pork sausage, turkey a la king, or thickened chicken broth. Glutamate was less readily detected in chicken broth or turkey a la king containing the higher of two levels of NaCl, but limited tests on cream of chicken broth and liver paste showed no effect of NaCl level within reasonable levels of variation. However, high levels of added thickenings, fat, or seasonings did not interfere with detection of added glutamate to any greater extent than did low levels. In fact, a high level of flour added to a highly seasoned broth made detection of added glutamate easier, probably because it masked some of the other seasonings. Ease of detecting added glutamate is not greatly influenced by variation in levels of thickening agent, fat content, or seasonings. Added glutamate was much more difficult to detect in foods normally containing very high levels of glutamate than in those containing very low levels. The glutamate content of the foods must be considered in developing recommendations for levels of added glutamate. Foods with very high glutamate content require considerably more added glutamate than foods with very low glutamate content to exhibit a demonstrable change in flavor. The extent of consumer preference for glutamate-containing samples did not vary in a consistent manner with NaCl level, but it is suggested that the preference decreases somewhat as the optimum acceptable NaCl level is approached. This level, of course, varies for different foods and individuals. In the foods tested, the preference for those with added glutamate either equalled or exceeded preference for those without added glutamate. The difference in performance of a trained panel on a paired comparison and a single sample test suggests that consumer tests of preference based on samples compared directly may have limited applicability under normal eating conditions. (See page 320).

Sensory evaluation *Monosodium glutamate*

Monosodium glutamate studies. II. Evaluation of a possible flavor stabilizing effect of glutamate in frozen foods and of the stability of glutamate to commercial canning process. Helen L. Hanson, Marian J. Brushway, and Hans Lineweaver.

Monosodium glutamate at 0.15 or 0.35% did not prevent or delay off-flavor development at 10° F in fried chicken held 4 months; turkey a la king, 9 months; raw turkey, 9 months; or pork sausage, 4 months; or in pork sausage held 4 months at 20° F. Nor did it retard peroxide development at 10° F in fried chicken held 1 year; turkey a la king, 15 months; uncooked turkey, 9 months; or pork sausage, 9 months; or pork sausage held 6 months at 20° F. The presence of glutamate neither prevented peroxide development nor did it mask the flavor changes that occurred. No loss in glutamate content was found in chicken broth, cream of chicken soup, or green beans subjected to commercial canning conditions. No flavor differences were detected between two samples of chicken broth or cream of chicken soup prepared by adding equal amounts of glutamate before and after canning, respectively. Since glutamate is stable to heat processing and since it does not affect the usual processing changes in the product as judged from this limited study, addition prior to canning, as is generally recommended, is indicated to assure uniform distribution, especially in heterogeneous products. (See page 328).



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Product research — *Tofu*

Tofu from Japanese and United States soybeans. Allan K. Smith, Tokuji Watanabe, and Arlo M. Nash.

Tofu made in pilot-plant investigations from different varieties of U. S. and Japanese soybeans showed observable differences in color and texture. Because uncomposited samples of soybeans were used, observed differences may have been caused by climate and soil at the location of their growth. Lee and Jackson varieties appeared to make tofu equal to that from Japanese soybeans. Tofu from several other U. S. varieties were only slightly different in color and texture. Yield of tofu varies with variety (location), but the general average yield from U. S. soybeans is about the same as from Japanese beans. Original protein and oil content of the beans is a factor in yield and in the final protein and oil content of the tofu. (See page 332).

Freshness test — *Iced shrimp*

The picric acid turbidity test: A possible practical freshness test for iced shrimp. Caroline H. Kurtzman and Donald G. Snyder.

An approach of possible usefulness in developing a satisfactory freshness test for iced shrimp was discovered by chance during the course of a well-known preparatory procedure for the analyses of free amino acids of spoiled and unspoiled shrimp. The procedure consisted of precipitating protein with 75% ethanol, heating, and adding saturated aqueous picric acid solution to permit the determination of free amino acids in the clear supernatants obtained after centrifugation. Clear supernatants were derived from unspoiled shrimp; quite turbid supernatants, from spoiled shrimp. This observation stimulated study of a procedure, based on this finding, that could be used, as a freshness test for iced shrimp. (See page 337).

Methodology — *Bacterial colonies masked by food particles*

A technique utilizing 2,3,5 triphenyltetrazolium chloride for recognition of bacterial colonies in the presence of large numbers of food particles. Myron Solberg and B. E. Proctor.

After plate cultures of food products have been prepared in accordance with standard methods and incubation has been completed, the ease of colony recognition is a function of the sample dilution. To the naked eye, the medium in which bacterial colonies have grown may vary from total opacity to complete transparency. In cultures prepared from low dilutions of food products, bacterial colonies may be masked by food particles or food particles may appear to be bacterial colonies. In order to eliminate these problems the Tetrazolium Flooding Technique was developed. In this method, each culture of plated food material, after proper incubation, is removed from the incubator and flooded with 2 ml of a 0.1% aqueous solution of 2,3,5 triphenyltetrazolium chloride. The flooded plate is gently rocked back and forth and from side to side several times so that the entire area is covered by the solution. The excess solution is poured off, the Petri dish cover replaced, the plate inverted and allowed to remain at room temperature for 3 to 5 hours. The metabolizing bacterial colonies normally reduce the indicated solution within the first hour. The additional time used allows the more slowly metabolizing colonies to reduce the tetrazolium and also results in color intensification within all of the colonies. In counting the colonies an illuminating instrument such as the Quebec Colony Counter can be used except in the case of extremely opaque media. (See page 343).

Quality improvement — *Red tart cherries for freezing or canning*

Factors affecting the drained weight and firmness of red tart cherries. R. L. LaBelle and J. C. Moyer.

Factors found to influence the firmness and drained weight of frozen or canned cherries are time elapsed between harvest and packing, degree of bruising, and fruit maturity. Prolonged holding time provides progressively higher character scores and drained weights in the processed products, whereas the ripening of the fruit has opposite effects. Although bruising also tends to augment firmness in the final product, it has the disadvantage of promoting decidedly greater scald. No difference was found between the firming effects of holding in air as compared to soaking in water. Neither were any significant differences in firmness observed when holding or soaking temperatures of 40 and 80° F were compared. The higher temperature merely encouraged scald damage. In general, conditions which favor high drained weight and firmness in red tart cherries are also conducive to

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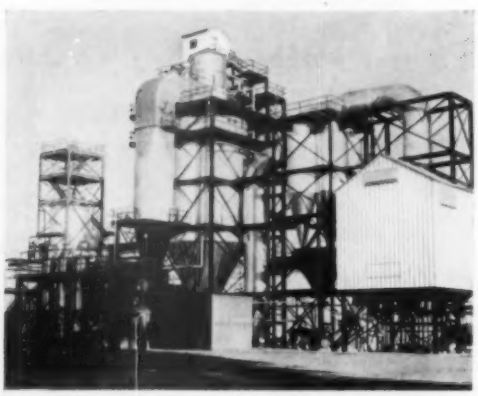

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scald and adversely affect color. As a compromise between these two quality objectives, it is suggested that cherries be handled with minimal bruising and be promptly chilled and soaked in cold water for moderate periods of 4 to 10 hours. (See page 347).

Quality study — *Bottled dry white table wines*

Effects of sulfur dioxide, temperature, time, and closures on the quality of bottled dry white table wines. C. S. Ough, E. B. Roessler, and M. A. Amerine.

In wine stored with cork closures, at two sulfur dioxide levels and at temperatures of 32°, 53°, and 70° F the relative free and total sulfur dioxide changed only slightly in a 22-month period. In general, cork-closed wines at the lowest storage temperature received the best scores; specifically, the 32° F storage temperature resulted in a significantly better mean score than did the higher temperatures. Wine quality also varied with sulfur dioxide level. Wines stored at the lower sulfur dioxide level (100 mg per liter) were of significantly better quality than wines stored at the higher level (250 mg per liter). In general, wine quality deteriorated with time of storage. Sulfur dioxide content at the higher levels declined more rapidly with metal than with cork closures. Storage temperature speeded the decline. Again, time of storage and sulfur dioxide levels caused significant differences in quality. In this experiment no significant effects on wine quality were found from closures or from the three lowest storage temperatures. Storage at 120° F was very detrimental to wine quality in all cases. (See page 352).

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Chemical and physical measurement — *Changes in green beans during preparing, processing*

Chemical and physical changes in green beans during preparation and processing. William A. Sistrunk and R. F. Cain.

A study of the effects of size and variety of beans and the temperature and time of blanch on the chemical constituents in blanched and canned beans showed these constituents to be related to texture in the canned beans. Texture was measured by per cent of sloughed skins and resistance to shear. AIS was not correlated with either firmness or sloughing of canned beans. Total and reducing sugars of canned beans reached a minimum when beans were blanched at 150° to 170° F, the temperature range at which the texture was firmest and the percentage of sloughed skins was lowest; yet this relationship was not established at other blanching temperatures. Low starch content was found in this range of blanching temperatures, and high starch values in the range of 180° to 200° F. Most texture changes in canned beans appeared to be related to changes in pectic substances during blanching and canning. Resistance to shear increased with an increase in per cent of pectate-pectinates, a highly significant positive correlation that existed in both phases of the experiment. Conversely, percentage of sloughed skins in canned beans was negatively correlated with percentage of pectate-pectinates and alkali-soluble pectins. The resistance to shear of canned beans of individual treatments was greater in the FM-1 strain than Asgrow Regular variety. Furthermore, the skins of the sieve size 5 canned beans of Asgrow Regular sloughed more than FM-1, but the reverse was true in sieve size 1 beans. Blanching at temperatures between 170° and 180° F for a time of 1.5 to 5 minutes was optimum for pole snap beans. Since the percentages of sloughed skins and resistance to shear of canned beans were affected by temperature of blanch, time of blanch, size of beans, and variety, optimum blanch was conditioned by these factors. Closer control over the raw material was apparent in order to prevent squeakiness and off-flavor in beans that were under-blanched as well as softness and sloughing in beans that were over-blanched. Adjustments in temperature of blanch or time of blanch within this temperature range should be sufficient for controlling sloughing and softening in pole snap beans for canning. (See page 357).

High-temperature, short-time sterilization — *Low-acid products*

Low temperature handling of sterilized foods. I. Design of equipment and outline of processes used. Arnold I. Epstein, C. Olin Ball.

Two systems for the high-temperature, short-time sterilization of some low acid products are discussed. The first system is a batch operation for the production of laboratory-size quantities of HTST sterilized products. The second system simulates a continuous procedure and is capable of processing material by several different methods which are feasible for commercial application. Both systems are capable of handling liquid, semi-liquid, and discrete particle products. (See page 363).

Sensory evaluation — *Constancy of panel sensitivity over prolonged periods*

Performance of flavor judges in long-term studies with frozen cauliflower and spinach. Mildred M. Boggs, Delpha W. Venstrom, Jean G. Harris, and Sumiko Shinoda.

This short note presents results of tests to determine the constancy of panel sensitivity in taste-tests over prolonged periods. Panels were tested at the beginning and at the end of 14-month studies with cauliflower and spinach. (See page 366).

Frozen food technology — *Moisture loss from packages*

Moisture loss from packages of frozen vegetables. Marvel-Dare Nutting, W. C. Dietrich, and R. L. Olson.

Procedures and observations in this note are intended to supplement data on product stability of frozen peas, green snap beans, spinach, and cauliflower. It seems unlikely that desiccation can play an important role in quality deterioration under commercial conditions unless packaging materials are permeable to moisture to a greater than average degree. (See page 367).

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1960

August 29-September 9	Second International Course on Lyophilization, Lyon, France
September 1-7	Fifth International Congress on Nutrition, Washington, D. C.
September 11-16	American Chemical Society's 138th national meeting, New York, New York
September 20-21	Military-Industry Conference on Freeze-Drying and other Dehydration Methods of Food Preservation, Sponsored by Research and Development Associates, Stock Yard Inn, Chicago, Illinois
September 20-23	Pure Food Centenary, Royal Institution of Great Britain, London, England
October 4-7	Tenth Annual Instrument Symposium and Research Equipment Exhibit, National Institutes of Health, Bethesda, Maryland
October 12-14	The Seventh National Symposium of the American Vacuum Society, Cleveland-Sheraton Hotel, Cleveland, Ohio

1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 10–14	**Twenty-second Annual Meeting of the Institute of Food Technologists, Fontainebleau Hotel, Eden Roc Hotel, Miami Beach, Florida**
1963	
May 19–23	**Twenty-third Annual Meeting of the Institute of Food Technologists, Pantlind Hotel, Civic Auditorium, Grand Rapids, Michigan**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

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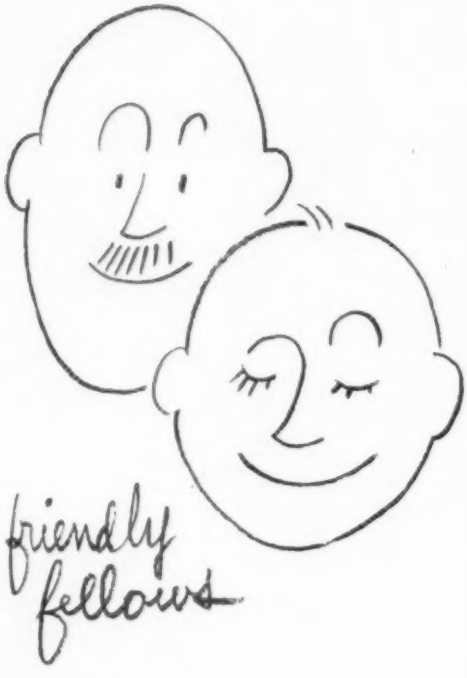

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IFT News

Dr. Harold W. Schultz, Head of the Department of Food and Dairy Technology at Oregon State College, Corvallis, was installed as President-elect of the Institute of Food Technologists at the May meeting of IFT in San Francisco. He will become President at the 1961 meeting in New York. His election was announced in May following mail balloting by the 6,000 Institute members.

During his two years as President-elect and President, Dr. Schultz will visit and speak before the 27 sections of IFT in this country and the British Columbia Section. IFT also has sections in Hawaii, Mexico, Japan and Australia.

Dr. Schultz has been Head of the Department of Food and Dairy Technology at Oregon State College since 1953. Before that, he had been with Swift and Company Research Laboratories in Chicago, Ill., for 11 years—four years in charge of the nutrition research division and seven years in charge of the meats for babies and table-ready meats research division.

H. W. Schultz

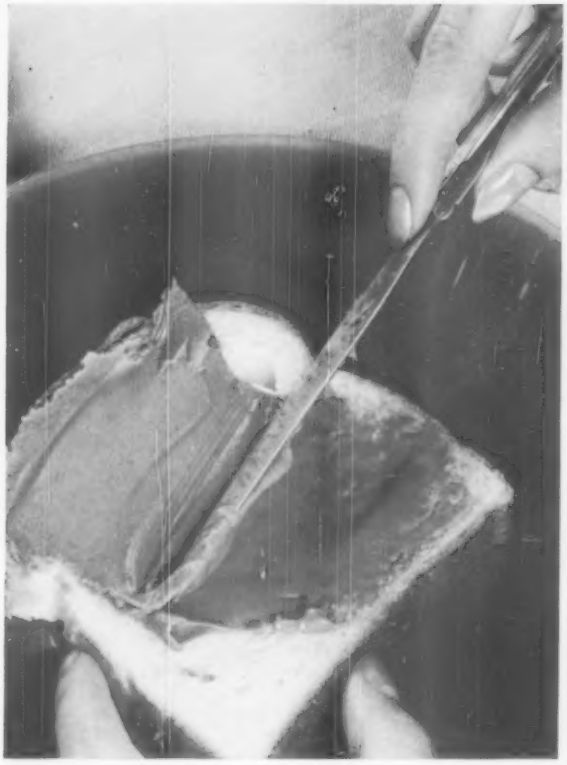
Dr. Schultz received his Bachelor's Degree from Colorado College in 1933; his Master's Degree with major in biochemistry from Iowa State University in 1935; and his Doctor's Degree from Iowa State in 1937.

He was an instructor in biochemistry at Iowa State for a year and later was instructor in physiology at Ohio State University College of Medicine for three years. From 1940 to 1942, he was research biochemist with Arthur D. Little, Inc., consultant chemists and engineers, Cambridge, Mass., before joining Swift and Company.

Principal areas of research by Schultz over the years have included separation of vitamins from foods; nutritional values of proteins; method of determination of nutritional values of foods; chemistry of foods and food processing; formulation, development, and manufacture of foods; meat chemistry and technology; and irradiation sterilization of foods.

Dr. Schultz is a member of numerous professional and honor societies including Sigma Xi; Phi Kappa Phi; Phi Lambda Upsilon; Phi Tau Sigma; American Chemical Society; American Association for Advancement of Science; American Dairy Science Association; American Public Health Association.

He has served on various committees of the Institute of Food Technologists and as a member of the advisory committees for the National Research Council, Refrigeration Research Foundation, and Quartermaster Food and Container Institute for the Armed Forces.



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The Thiobarbituric Acid Test in Irradiation-Sterilized Beef[a, b]

Norman L. Smith,[c] Ian J. Tinsley, and E. C. Bubl

Department of Agricultural Chemistry, Oregon State College, Corvallis, Oregon.

(Manuscript received February 8, 1960)

THE THIOBARBITURIC ACID (TBA) color reaction has been used extensively to measure rancidity in lipide containing products *(8, 9)*. This same reaction has also been used as a measure of the changes induced in products sterilized with ionizing radiation. Wertheim and Proctor *(11)* investigated the nature of the TBA reaction with gamma-irradiated milk. These workers concluded that although the TBA reaction correlated with the level of irradiation, the irradiation induced TBA reactants were not associated with the off-flavors developed. Similar results have been obtained in a study of the TBA reaction in irradiated beef *(2)*.

Malonaldehyde has been suggested as the component in lipid containing products which is responsible for the red color formed with thiobarbituric acid *(4, 6, 7)*. A number of compounds, in addition to malonaldehyde, known to produce a red color with this reagent have been summarized by Smith *(9)*. Such compounds would include glyoxal, paradimethylaminobenzaldehyde and various pyrimidines. This work has been designed to study the nature of the TBA reaction with irradiated beef.

EXPERIMENTAL PROCEDURES

Preparation and irradiation of samples. Commercially ground beef samples containing approximately 70% moisture and 15% fat were obtained from the Nebergal Packing plant in Albany, Oregon. Approximately 450 g of sample were placed in a No 2 C-enamel can and vacuum sealed. The cans were frozen and shipped to the Materials Testing Reactor at Idaho Falls, Idaho, where the samples received the specified dose. Spent fuel rods were the radiation source. The samples were shipped to Oregon State College in the frozen state and held frozen until used.

Thiobarbituric acid reagent. Thiobarbituric acid reagent referred to in the following procedures was prepared using 0.72% 2-thiobarbituric acid (EK.Co. No. 660) (w/v), with aqueous 15% trichloroacetic acid (TCA) as the solvent. Fresh reagent was made up before each experiment; solutions older than 12–15 hr were not used. When reacted with meat samples, a ratio of 25 ml reagent per 10 g of meat was always used.

Spectrophotometer measurements. Observations were carried out either on the Beckman Model B or the Beckman Model DU spectrophotometer. In some cases a Bausch and Lomb filter colorimeter was used with a 525 mμ filter. In the later stages of the experiment a Cary Model 11 recording spectrophotometer was used.

RESULTS

1. Spectrophotometric and chromatographic studies. On heating a sample of irradiated beef with the TBA reagent in boiling water, cooling and centrifuging, the supernatant turns an orange color. The effect of heating time on color development is shown in Figure 1. Absorption maxima are observed at 454 mμ and 534 mμ.

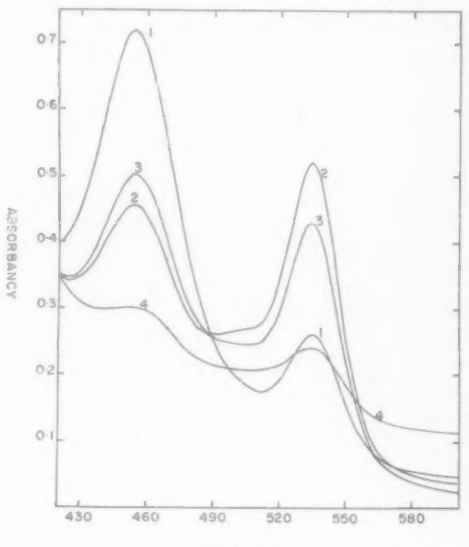

Figure 1. Effect of heating time at 100° C on the TBA reaction with beef irradiated at 3.7 x 10⁶ rad. 1, 5 min; 2, 10 min; 3, 20 min; 4, 60 min.

After 5 min heating, a strong absorption at 454 mμ is observed which decreases on further heating and then increases again. It is proposed that the initial absorption at 454 mμ is due to a primary compound formed with thiobarbituric acid and the reacting component(s) which in turn is converted into a compound absorbing at higher wave lengths. If glyoxal is allowed to react at room temperature with the TBA reagent or for short periods at boiling water temperature, a compound absorbing at 454 mμ is observed. Further heating results in the production of compounds with absorption maxima at 525 and 552 mμ (Figure 2). Even when malonaldehyde is allowed to react with the TBA reagent at room temperature, no absorption maximum in the region of 450 mμ is observed. The compound giving rise to the 534 mμ absorption maximum appears to be formed directly. The increase in absorption at 454 mμ after longer periods of heating, as has been observed previously *(3)*, is due to carbohydrate material.

The absorbancy at 534 mμ reaches a maximum after 10–15 min heating in a boiling water bath. The absorption in this area has been shown to correlate with the level of irradiation

[a] Technical paper No. 1226, Oregon Agricultural Experiment Station.

[b] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces and has been assigned number 1061 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or endorsement of the Department of Defense.

[c] Now at Health Chemistry Department, University of California, Lawrence Radiation Laboratory, Livermore, California.

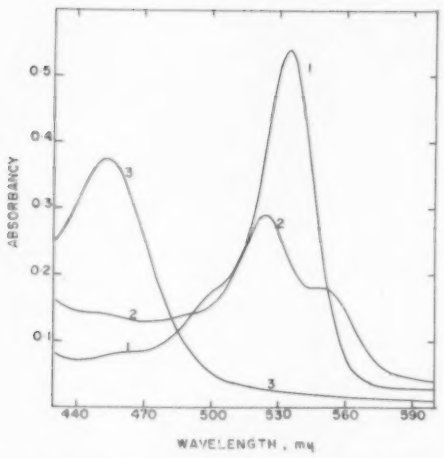

Figure 2. Spectral curves of glyoxal-TBA and malonaldehyde-TBA pigments. 1—malonaldehyde; 2—glyoxal-reaction carried out 100° C for 10 min; 3—glyoxal-reaction carried out at room temperature for 24 hours.

(3) and thus the nature of the components giving rise to this absorption maximum have been investigated more thoroughly. The absorption maximum at 534 mmc corresponds to that of malonaldehyde-TBA pigment (Figure 2); however, chromatographic experiments have indicated that a glyoxal-TBA pigment also contributes to the absorption in this region.

The pigment absorbing at 534 mmc was purified by absorption on cellulose powder *(3)* eliminating the yellow pigment present in the reaction mixture which is not absorbed. The cellulose on which the pigment was absorbed was dried and then extracted with ether in a Soxhlet apparatus to remove any excess free thiobarbituric acid. The pigment was eluted from the cellulose with warm water and evaporated to dryness under vacuum, giving an amorphous red powder.

The purified pigment obtained from the irradiated meat sample was compared on paper chromatograms with pigments prepared from glyoxal and malonaldehyde. Two different solvents were used, No 1, isopropanol (10 parts), 98% formic acid (10 parts), water (100 parts), and phenol (80 parts) on a weight for weight basis, and No. 2, phenol saturated with water. System No. 1 was allowed to equilibrate for 24 hr and the upper fraction was used. The use of borate buffered papers at pH 8.7 was found to give improved definition of spots in these solvent systems.

The R_f values of the different pigments and absorption maxima determined after elution of the spots are given in Table 1.

TABLE 1

R_f values and absorption maxima of TBA-pigments separated by paper chromatography

Spot	R_f		Absorption max mmc
	Solvent No 1	Solvent No 2	
Meat-TBA No 1	.13	.28	534
Meat-TBA No 2	.25	.08	552
Malonaldehyde TBA	.14	.27	534
Glyoxal-TBA No 1	.24	.08	552
Glyoxal-TBA No 2	.45	.06	525

The two spots separated from the purified meat-TBA pigment thus corresponded to the malonaldehyde-TBA pigment and to one of the pigments produced in the reaction of thiobarbituric acid and glyoxal.

2. Nature of thiobarbituric acid pigment precursors in irradiated beef. To obtain some information regarding the nature of the TBA pigment precursors of irradiated beef, the extraction scheme of Figure 3 was followed.

The chloroform extract was prepared by mixing the sample in a Waring blender, shaking for 15 min and finally centrifuging. Preliminary experiments had indicated that one such extraction was adequate to remove the chloroform-soluble thiobarbituric acid pigment precursors. Aliquots of the 4 residual fractions were treated with the TBA reagent and the absorbancy at 525 mmc determined. The percentage of color forming components in each fraction is indicated in Figure 1.

After extraction with both chloroform and water a considerable portion of the TBA pigment precursors was retained in the solid residue. Apparently this portion is bound in some insoluble form. The following experiment was carried out to determine the efficacy of trichloroacetic acid hydrolysis in releasing these components.

Duplicate portions of irradiated meat were refluxed for 25 min, one in 15% trichloracetic acid and the other in distilled water as a control. The residues were filtered off and extracted with chloroform. Aliquots of the aqueous extracts, chloroform extracts and the residue were treated with the TBA reagent and the absorbancy at 525 mmc measured. The percentage of the total pigment formed is tabulated for each fraction in Table 2.

It is apparent that the trichloracetic acid treatment effectively releases the greater portion of the bound TBA pigment precursors in a water soluble form.

The effect of dialysis on the distribution of the TBA pigment precursors was also studied. After blending a portion of the irradiated meat in water with a Waring blender, the tissue

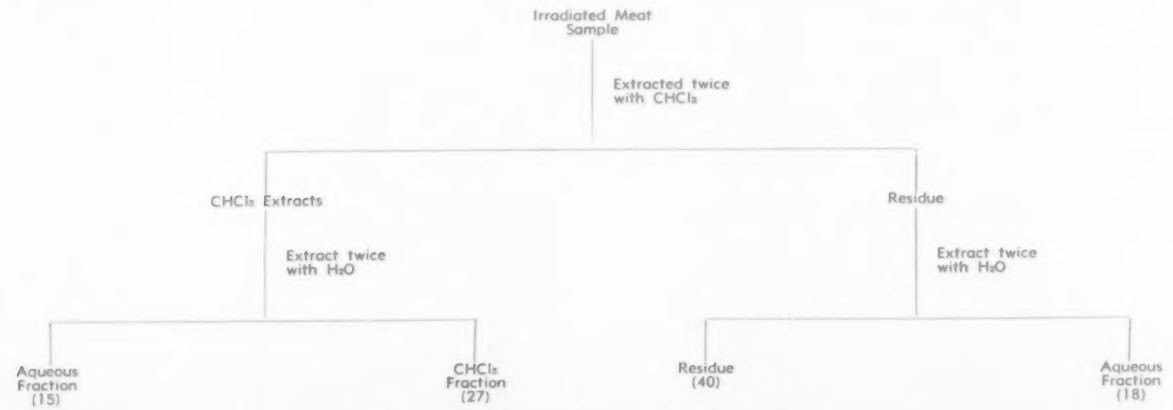

Figure 3. Extraction scheme for irradiated beef.

TABLE 2

Per cent of total absorbancy at 525 mmc of different extracts of irradiated beef

	Trichloracetic acid treated	Distilled water
Aqueous	64	35
Chloroform	29	32
Residue	8	33

was further homogenized in a Potter-Elvehjem homogenizer. The fibrous material was removed and the homogenate divided into two portions. One portion was dialized in a cellophane bag against cold, running tap water for 25 hr. The second portion was refrigerated to act as a control sample. After dialysis both portions were treated with TBA reagent, diluted to the same volume and the absorbancy measured at 525 mmc. Dialysis for 25 hr resulted in a loss of 50% of the color-forming precursors. Extending the time of dialysis to 50 hr did not result in any further loss of the TBA pigment precursors. Comparing these results to the preceding experiment it would appear that dialysis results in a release of a further portion of the bound precursors.

Summarizing these experiments one is able to say that 25–30% of the color-forming precursors are present in a chloroform soluble form, another 30–35% are water soluble. A considerable portion of the latter is also soluble in chloroform, possibly as a phospholipide type complex. A large portion of the color-forming precursors remain bound in an insoluble form. Prolonged dialyses releases a portion of the bound color-forming precursors but refluxing with 15% trichloracetic acid results in the release of almost all the color-forming precursors from the extracted residue.

DISCUSSION

Irradiation of beef with γ-rays induces the formation of components which react with thiobarbituric acid to give an intense red color. Two red pigments have been isolated from the reaction mixture, one with an absorption maximum at 534 mmc and the other with an absorption maximum at 552 mmc. The former corresponds to the pigment produced from the reaction of malonaldehyde with thiobarbituric acid. The latter is identical with one of the two red pigments produced from the reaction of glyoxal with thiobarbituric acid. The reason that the two glyoxal type pigments are not observed in the meat-TBA system is not known. It is possible that conditions prevailing in the meat-TBA system differ from those of a model system of glyoxal-TBA to such a degree that the pigment with an absorption maximum at 525 mmc is not formed in the former system. Several observations would lend support to this hypothesis.

Two identical samples of irradiated beef were taken and to one was added a known amount of glyoxal. Both samples were then reacted in the usual manner with TBA reagent and a difference spectrum was obtained, comparing the meat plus glyoxal system to the straight meat systetm. In the absence of any modification of the glyoxal-TBA reaction in the presence of the meat, the difference spectrum should corespond to the spectrum obtained by reacting an equivalent amount of glyoxal with the TBA reagent under similar conditions. The difference spectrum shows absorption maxima at 525 and 552 mmc characteristic of the glyoxal-TBA system, however in comparison with the latter the absorption at 525 mmc is considerably reduced.

Some studies in model systems of the reaction of glyoxal with thiobarbituric indicate that the concentrations of the two pigments formed is modified by the concentration of thiobarbituric acid in the reaction mixture. Over the concentration range at which the absorption at 552 mmc remains constant a decrease in thiobarbituric acid concentration results in a marked decrease in absorbance at 525 mmc. In a meat sample there are many extraneous components which might react with the thiobarbituric acid, thus reducing the effective thiobarbituric acid concentration relative to the reaction of glyoxal with thiobarbituric acid in a model system. Additional evidence for the presence of glyoxal in irradiated beef has been obtained using the specific colorimetric test described by Ariyama *(1)*.

The form of the thiobarbituric acid reactants in the beef samples is not well defined. Some are fairly weakly bound, being removed by dialysis, whereas a large proportion of these components are in a bound form; only being released by acid hydrolysis. The fact that a large percentage of these components is tightly bound and only released under rather drastic conditions might account for the failure to correlate the TBA test with sensory evaluation of off-flavors induced by this process.

Irradiation induced oxidation of polyunsaturated fatty acids in which the double bonds are separated by a methylene group could give rise to a 3 carbon fragment corresponding to malonaldehyde. With migration of double bonds in the oxidation process it is possible to account for the formation of a two carbon fragment corresponding to glyoxal. In addition, glyoxal has been identified as a breakdown product of irradiated serine *(10)* and also of irradiated glucose *(5)*. Hence, the glyoxal of irradiated beef could be derived from proteinaceous as well as carbohydrate and lipide material. At the present time the TBA reaction resulting in the formation of the 534 mmc absorption maximum constitutes the only evidence for the formation of the 3 carbon fragment in oxidized lipide containing products.

SUMMARY

Beef, irradiated with γ-rays gives an intense color reaction with thiobarbituric acid. The red color produced in this reaction has been shown to be due to the formation of two pigments with absorption maxima at 534 mmc and 552 mmc. The former corresponded to the pigment produced in the reaction of malonaldehyde with thiobarbituric acid and the latter corresponds to one of the pigments produced in the reaction of glyoxal with thiobarbituric acid. Some studies have been made of the nature of the color precursors in the irradiated beef.

LITERATURE CITED

1. Ariyama, Noboru. Studies on glyoxals. *J. Biol. Chem.*, **77**, 359 (1928).

2. Cain, R. F., Bubl, E. C., and Anderson, A. W. The effect of intermittent radiation and concomitant increase in temperature during radiation on the acceptability of ground beef. *Food Technol.*, 10, 537 (1956).
3. Caldwell, E. F., and Grogg, B. Application of the thiobarbituric acid test to cereal and baked products. *Food Technol.*, 9, 185 (1955).
4. Patton, Stuart, and Kurtz, George W. 2-Thiobarbituric acid as a reagent for detecting milk fat oxidation. *J. Dairy Sci.*, 34, 669 (1951).
5. Phillips, G. O., Moody, G. J., and Mattok, G. L. Radiation chemistry of carbohydrates. Part I. Action of ionizing radiation on aqueous solutions of D-glucose. *J. Chem. Soc.*, 1958, 3522.
6. Sinnhuber, Russel O. (Personal communication).
7. Sinnhuber, Russel O., and Yu, T. C. 2-Thiobarbituric acid method for the measurement of rancidity in fishery products. II. The quantitative determination of malonaldehyde. *Food Technol.*, 12, 9 (1958).
8. Sinnhuber, Russel O., Yu, T. C., and Yu Te Chang. Characterization of the red pigment formed in the 2-thiobarbituric acid determination of oxidative rancidity. *Food Research*, 23, 626 (1958).
9. Smith, Norman L. (M.S. thesis, Oregon State College, 1958).
10. Stein, Gabriel, and Weiss, Joseph. Chemical actions of ionizing radiation on aqueous solutions. IV. The action of x-rays on some amino acids. *J. Chem. Soc.*, 1949, 3256.
11. Wertheim, J. H., and Proctor, B. E. Radiation preservation of milk products. III. The thiobarbituric acid test as a means of evaluating radiation-induced changes in milk. *J. Dairy Sci.*, 39, 391 (1956).

Monosodium Glutamate Studies. I.

Factors Affecting Detection of and Preference for Added Glutamate in Foods

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This study of monosodium glutamate as a food flavor adjunct and as a possible flavor stabilizing agent in stored products was an attempt to resolve some of the conflicting reports and views in popular and technical literature on glutamate properties. Mosel and Kantrowitz *(10)* after discussing reasons for some of the confusion regarding taste properties of glutamate, stated that "the only thing that seems certain from existing data is that MSG can change the flavor of food, usually in the direction of increased palatability." It is generally agreed that glutamate has a "sweet salty" taste, but beyond that there is considerable uncertainty. Differences in objectives of the various studies as well as differences in methods contribute to the uncertainty. Some published reports are based on casual observation and individual opinion; others are limited to tests of threshold values or detection of differences at subthreshold concentration in water.

Interest in glutamate has a distinctly practical basis because of obvious economic implications. Potential users need assurance that by addition of glutamate they are adding something to their products that could not be accomplished more cheaply by the addition of salt. It is also important to know to what extent salt, fat, seasoning, and thickening levels of a product influence effectiveness of added glutamate, whether recommended levels must be adjusted for formula variations, and the reason for different recommended levels in various products. A level of 0.15% is recommended for most products, but levels as low as 0.10 and as high as 0.25% are recommended for a few *(1, 2)*. If glutamate has the antioxidant properties reported *(13)*, comparison with other antioxidants would be in order. Because of its wide usage in canned products, assurance that it is not lost or altered in commercial heat processing would be appreciated.

The interrelation between NaCl and glutamate has aroused the interest of a number of investigators; a few have studied the effect of fat, thickenings, and seasonings on detection of glutamate. Sjöström *et al (15)* reported that while glutamate has some salt value, it cannot fully replace salt in foods. They and others *(3, 6)* reported that the effect of glutamate on saltiness and other flavors varied with the concentra-

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tion of added glutamate, the level of salt, and the character of the original product. Lockhart and Gainer *(9)* found no increase in the saltiness of NaCl solutions by the addition of subthreshold glutamate levels. Crocker *(4)* in tests with over a dozen amino acids, reported that saltiness was evident only in the sodium salt of L (+) glutamic acid. Fellers *(5)* stated that excessive salt covers up the glutamate flavor. Galvin *(7)* expressed the view, after studies on simple systems using a distilled water base, that particular attention should be paid to salt, pH, and sweetness to obtain maximum benefit from glutamate. He also stated that salt must be present to produce a useful glutamate taste. Mosel and Kantrowitz *(10)* found that exposure to a 5-threshold solution of glutamate did not affect taste acuity to NaCl.

Nair *(11)* reported that in the presence of thickening agents such as gums, flour, and starches, higher glutamate levels are required than in unthickened products. He stated that thickening agents act as diluents of flavor and may selectively mask certain flavors more than others. Cairncross *(3)* reported that 1% solutions of carboxymethyl cellulose suppressed the effect of low concentrations of glutamate. He also reported that addition of fat to well-seasoned nonmeat gravies thickened with cereal thickening agents suppressed flavor, and that glutamate has more influence in fat-free foods than it has when fat is present. Fellers *(5)* reported that in fish pastes and sandwich spreads as much as 1% glutamate can be used, a considerably higher level than he suggested for other fish products. The composition of the pastes and spreads was not indicated, and no reason for the higher recommended level was suggested.

The studies reported in this paper were designed to assess the relative influence of these and other factors on the detection of glutamate. They have confirmed that a number of factors have some influence on effectiveness of glutamate addition, and have demonstrated that the inherent level of glutamate in the product has a major influence on the effectiveness of added glutamate. However, in the final analysis the usefulness of adding glutamate will depend on whether it has a favorable effect on consumer preference for the food under consideration, and particularly whether supplements of glutamate have a more favorable effect on consumer preference for foods than can be obtained by supplements of less expensive NaCl. Therefore, limited consumer-type tests have been conducted, the results of which should indicate the usefulness of more extensive tests under particular conditions.

METHODS

Sensory tests. Most of the studies reported here are based on detection of added glutamate, conducted with a panel of judges selected for acuity in detecting added glutamate in side-by-side comparison of products, with and without added glutamate. Relative ease of detection is considered reflected by frequency of detection. Approximately 40 members of the laboratory staff were tested for their ability to detect glutamate in various products, and the best of these (about one-third) were used, 6 to 10 per panel.

The duo-trio test was used for selection of the judges and for the experiments. In this test sample X containing no glutamate, was presented, labeled, as the control. Samples X and Y were presented, coded, in either of the possible orders: XY, YX. Each judge received the samples an equal number of times in both orders and was asked to identify the sample that was the same as the control. Since identification of X constituted detection of the added glutamate in Y, the results are reported in the table as detection of added glutamate. Ordinarily, two pairs of samples are presented in this test with the control. Based on more efficient use of the judges' time, presentation of 3 pairs at each testing period seemed desirable if it could be done without affecting the results. However, there were reports in the literature on a "persistence" of the glutamate effect that might interfere with detection of added glutamate in the second and third pairs more than in the first pair, and it was felt that judges' fatigue might operate in the same way. Therefore, the tests were conducted so that these factors could be analyzed and, if necessary, only results of the first pair would be used. The compilation of correct judgments in Table 1 showed that the judges were not affected by either a "persistence" effect of glutamate or fatigue, and that results of all pairs could be used.

TABLE 1

Equivalence of judgments for pairs of samples submitted consecutively

Product	Total judgments each pair	Correct judgments		
		First pair	Second pair	Third pair
Chicken broths, turkey a la king, sausage, beans, peas	208	198	213	214
Goose liver paste	45	30	25	
Dehydrofrozen peas	17	11	11	9
Crab and cheese sauce	72	45	40	44
Pork sausage	79	54	48	
Cream of chicken soup	80	66	64	
Chicken liver paste	81	38	42	
Total		442	443	

Because of the relatively small number of reasonably "average consumers" available at the laboratory, the consumer test was limited. The consumers were members of the staff who were not on the selected glutamate panel and had no particular knowledge of the experiment. Fifty to 100 individuals were asked to indicate which of two samples they preferred on each comparison. The order of presentation was randomized.

Although consumer tests are usually based on a preference decision between samples compared directly at the same time, such a test does not show the preference under less ideal conditions. Under practical conditions of consumption, for example, foods with and without glutamate would not be compared at the same time. They would be served in larger portions and with other foods. These interesting questions could not be adequately explored. However, an experiment comparing two methods of sample presentation was conducted, with the panel selected for ability to detect glutamate at low levels, to evaluate at least partially the significance of the memory factor in flavor judgments. In addition to presenting the samples side-by-side in the duo-trio test, single samples of broth and a la king were presented alternately for detection of added glutamate. Four test samples were presented at each sitting, two of broth and two of a la king. They were presented either in a duo-trio test (side-by-side comparison of each product with and without glutamate) or in a single sample test (alternately broth and a la king). The duo-trio test was conducted as previously described, with the control sample presented for direct comparison with pairs of samples, one of which contained glutamate and the other no glutamate. For the single sample test the judges were first given a control sample of broth or a control sample of a la king. They were asked to taste it and remember its flavor for comparison with subsequent samples. The sample was removed and a control of the other product, either a la kind or broth, was given with the same instructions. This control was removed. Then test samples of broth and a la king

were presented singly, alternating from one product to the other; judges were asked whether they were like or unlike the controls. The days on which this test was conducted were randomly interspersed among the days of the duo-trio test. Since the preliminary tests showed it was more difficult for the judges to determine differences with the single sample test than with side-by-side comparisons, higher levels of glutamate were used in the former.

Sample preparation. Preparation of products and formulas used in Sections A and C under "Results" are as follows:

Chicken broth. A uniform lot of hens (200) was simmered with 1 part of water per 1.8 parts of chicken in covered stainless steel kettles for 3 hours. The broth obtained was separated from the fat, canned without further heat processing, frozen, and stored at −20° F. until needed. Normal salt seasonings of either 0.50 or 0.75% were used in comparisons reported in Table 2, as these levels were considered neither too bland nor too salty by the panel. The following ingredients were added to the chicken broth for items 1–9 reported in Table 3:

1. None.
2. 0.5% carboxymethylcellulose.
3. 2.9% all purpose wheat flour.
4. No. 3 + 3.8% bland vegetable fat.
5. No. 3 + 3.8% chicken fat.
6. No. 4 + 0.04% pepper.
7. No. 6 + 0.02% sage, 0.04% onion salt.
8. No. 4 + 0.04% pepper, 0.02% sage, 2.2% diced onion, 9% diced celery, 14% rice.
9. No. 8, blended.

Glutamate was added by diluting with water to a 2% solution, and pipetting the necessary amounts into the soup and a la king. Water containing no glutamate was added to the control sample to give equal dilution.

Turkey a la king. Turkeys weighing approximately 20 lb. were simmered in water and deboned. A white sauce was prepared containing turkey stock, turkey fat, milk, flour, and salt. The turkey a la king as prepared contained the following ingredients:

Ingredient	Per cent
Turkey, deboned, diced	24.10
Turkey stock	33.10
Turkey fat (separated from the stock)	5.15
Flour, all purpose wheat	1.85
Waxy rice flour (to prevent separation during freezing)	2.62
Milk	19.16
Salt	0.76
Egg yolks, hard cooked, chopped	5.90
Onion, chopped, sauteed	0.53
Green pepper, chopped, sauteed	0.99
Canned mushrooms	3.78
Pimentos, canned, diced	2.06

Pork sausage. Pork trimmings obtained from a large commercial meat packing plant were ground twice (coarse and medium) through the meat grinder attachment of a No. A-200 Hobart mixer, and mixed for approximately 3 min on speed 1 with the dough hook. The seasoning mixture containing the following ingredients, expressed as per cent of sausage weight, was added before mixing and grinding:

Salt	1.0%
Pepper	0.2%
Sage	0.26%

This lot of sausage contained 60% fat. Salt and glutamate supplements were added with uniform mixing before cooking. Sausage was brought to the desired glutamate concentration by adding glutamate solution, which raised the moisture content 1%.

Frozen vegetables were cooked following package directions with 1.5% NaCl by weight of the vegetables added to the cooking water. Vegetables were drained, mixed, and separated for butter (3%) and glutamate addition. A 2% glutamate solution was added to one part of the melted butter. An equal amount of water was added to the butter to be mixed with the control. Total water added was about 1%. These butter-water-glutamate mixtures were added to the vegetables and thoroughly mixed.

One volume of dehydrofrozen peas was added to 3 volumes of cold water containing 1.63% NaCl and amounts of glutamate determined by preliminary analyses to be needed to assure the desired glutamate level in the peas served. They were brought to a boil and cooked for 8 minutes.

Crab was prepared in two forms: crab in cheese sauce and crab cakes. For the first product two parts of crab meat were added to 3 parts of medium thick white sauce containing 21% grated sharp cheddar cheese. The crab cakes contained crab meat, bread crumbs, whole eggs, chopped sauteed onion, oleo, mustard, Worcestershire sauce, and salt. The cakes were shaped, rolled in flour, deep fat fried until brown, frozen, and reheated as needed for the panel.

Goose liver paste was prepared by combining the following ingredients:

Ingredient	Per cent
Livers, steamed, ground	59.0
Onions, chopped, sauteed, ground	9.75
Oleomargarine	29.75
Salt	1.04
Thyme	0.086
Black pepper	0.086
Paprika	0.086
Nutmeg	0.172

The a la king, sausage, crab products, and liver paste were sealed in cans and stored at −20° F until needed.

For tests of NaCl addition reported in Table 4, chicken broth and turkey a la king were the same as in Table 3 with the indicated variations in levels of NaCl.

Cream of chicken soup was prepared by combining and bringing slowly to a boil the following ingredients:

Ingredient	Per cent
Chicken broth	88.90
Dry skim milk solids	7.20
Waxy rice flour	2.90
Salt	0.80
Onion powder	0.082
Black pepper	0.025
Sage	0.020

Levels of NaCl were varied as indicated in Table 4.

Chicken liver paste was prepared as the goose liver paste previously described, with indicated NaCl levels (Table 4). For the test of added seasonings, two levels were added to cream of chicken broth, the level above and half that level. Three levels were added to pork sausage, the level used previously, a lower, and a higher level (7 times the lower level). Two levels were added to the turkey-chicken liver paste. For the test of added thickenings, the cream of chicken soup formula above was used with the two levels of thickening indicated in Table 4. For the test of level of fat, chicken liver paste was prepared with and without added bland hydrogenated vegetable fat. Fat content of the former was estimated to be approximately 30% and of the latter, approximately 4%.

Blue lake *green beans*, size 4, were obtained with ends removed, from the line of a large commercial canning plant. The beans were washed, cut into approximately one inch pieces, steam blanched at 180° F for 1½ min, and cooled in a cold water spray. They were weighed into enameled cans, 303 x 404, and divided into groups for the addition of brines containing glutamate or varying amounts of NaCl, depending upon the level desired for consumer evaluation. On the assumption that the salt and glutamate added in the brine would become evenly distributed throughout the contents during canning, these ingredients were added in quantities required to give NaCl concentrations ranging from 0.8 to 1.0% and a glutamate concentration of 0.15% in the drained beans after processing. War-

burg analyses showed a glutamate content of 0.11 to 0.15% in the beans.

The base levels of NaCl used in the consumer test products were within the 0.5 to 1.0% levels used in the previous tests. Levels of glutamate that have been added to poultry products range from 0.09 to 0.75%. Levels recommended by the Glutamate Manufacturers' Technical Committee in their pamphlet, *The Value of Glutamate in Processed Meat and Poultry*, are 0.12 or 0.15% for the following products: whole frozen boned turkey, frozen chicken and turkey pies, frozen chicken a la king, canned whole chicken, canned boned chicken or turkey, canned chicken fricasee, canned chicken or turkey a la king, and fresh poultry *(1)*. The level of glutamate selected for these consumer tests was the higher of the recommended levels, 0.15%, and levels above 0.15% because of their interest if the 0.15% level showed no beneficial effect. One of each pair of samples was supplemented with glutamate, the other with 0 to 0.3% NaCl.

Determination of glutamate concentration. Glutamate concentration was determined by the enzymatic decarboxylation method of Rogers *et al (14)*. The enzyme used was prepared from *E. coli*, ATC 11246, according to Najjar *(12)*, modified to remove the glutamine, lysine, arginine, and histidine decarboxylase activities by incubating a 2% suspension of the original acetone powder in 0.3N acetate buffer (pH 5.0) at 35° C for 64 hr. Negative results on tests of the modified enzyme on these acids confirmed removal of decarboxylase activities. This suspension was frozen in 2 ml aliquots for use, since further handling greatly lowered the remaining glutamic acid decarboxylase activity.

Fifty grams of the product to be analyzed were homogenized in a blender with sufficient water (2 to 4 volumes) to permit accurate measurement. Analyses were conducted on 1.8 ml of this mixture, 0.5 ml of 0.1N acetate buffer, pH 5.1, and enzyme sufficient to complete the reaction in 30 to 45 min. The free glutamate concentration was expressed in micromoles of glutamate per gram of original sample.

RESULTS

A. Ease of detecting glutamate in foods of varying character, composition, and concentration of ingredients. Glutamate is normally used as a supplement to foods containing NaCl. Therefore, a test was designed to determine whether a supplement of monosodium glutamate was more readily detectable than a supplement of sodium chloride when these supplements were added to chicken broth containing normal amounts of NaCl. Judges compared chicken broths containing either 0.50 or 0.75% NaCl with these broths containing either added glutamate or added salt in amounts shown in Table 2. The amounts of added glutamate and added salt are nearly equimolar, and therefore contain nearly equivalent amounts of sodium ion, equalizing any taste effect of the sodium part of added glutamate or salt. The difference between the last two columns shows that added glutamate ion was more readily detected than added chloride ion in broth containing either 0.50 or 0.75% NaCl.

Results of this test not only demonstrated the characteristic flavor of the glutamate ion compared with the chloride ion but also supported the usefulness of further tests to determine how the flavor contribution of glutamate is influenced by salt level in the product, and whether this characteristic flavor, readily detected by a selected panel, influences consumer preference for samples containing both added glutamate and NaCl.

TABLE 2

Detection of added monosodium glutamate and chloride in nearly equimolar amounts, and hence nearly equal sodium concentrations, in chicken broth[1]

Amount of salt in stock broth	Glutamate addition		Salt addition		Detection of added glutamate[2]	Detection of added salt[2]
%	%	*mM/l*	%	*mM/l*	%	%
0.50	0.05	2.7	0.016	3.0	90	73
	0.10	5.4	0.032	6.0	100	71
	0.05	2.7	0.016	3.0	86	65
0.75	0.10	5.4	0.032	6.0	94	69
	0.25	13.5	0.080	15.0	96	88

[1] The orders of presenting products for both base levels of sodium chloride and for all sodium ion supplements were randomized together.

[2] The total number of judgments for each sample was 48 (duo-trio test comparing stock broth with broth containing additive). Per cent detections reported were all statistically significant at the 5% level or higher.

Glutamate was added to foods of varying character and composition to obtain information on factors that influence its detection. The levels of glutamate added were intended to be sufficiently above threshold levels for the panel members so that the relative ease of detecting glutamate in the foods would be apparent. The percentages of correct judgments differed considerably for equal additions of glutamate (Table 3, products 1–13), and larger amounts of glutamate were required for approximately equal detection in some foods than in others (products 14–17).

Glutamate was detected most readily in chicken broth, the simplest product tested. It was detected in 95% of the possible judgments by 3 panel members at a concentration of 0.015% and by the remainder at a concentration of 0.04%. Thickening, fat, and seasonings in the amounts added decreased the ease of detection to a small extent. Glutamate was readily detected even in pork sausage in spite of its higher flavor and seasoning content. But in frozen peas, glutamate was not detected at levels corresponding to those used in the various soups, turkey a la king, pork sausage, and frozen beans. The panel detected glutamate in the crab products less frequently than in all the previous products except peas; even higher levels of glutamate did not give equivalent detection. Glutamate was least frequently detected in the goose liver paste; 0.20% added glutamate was required for significant detection. The makeup of the panels was not always identical from one product to another because of absences, allergies, or dislike of some foods. Also, the total number of judgments differed. In spite of some variations, there seems little reason to doubt the generally less frequent (and therefore more difficult) detection in the crab products, peas, and goose liver paste.

The great difference in the ease with which glutamate was detected in products reported in Table 3 indicated the need for additional tests of the specific effects on glutamate detection of added NaCl, seasonings, fat, and thickenings in foods at levels at which these variables might reasonably be used. Chicken broth, turkey a la king, cream of chicken soup, and pork sausage were selected for tests of the effect of NaCl level on glutamate detection because NaCl could

TABLE 3

Relative ease of detecting glutamate in various food products[1]

Product	Total judgments	Added glutamate	Detection of added glutamate
		%	%
1. Chicken broth	84	0.015	95***[3]
2. Broth + carboxymethyl-cellulose	84	or	89***
3. Broth + flour	84	0.04[2]	81***
4. Broth, flour, bland vegetable fat	48		77***
5. Broth, flour, chicken fat	84		77***
6. No. 5 + pepper	48		77***
7. No. 6 + sage, onion salt	84		80***
8. No. 6 + sage, diced celery, onion, rice	48		77***
9. No. 8, blended	48		71**
10. Turkey a la king	48		73**
11. Pork sausage	48		73**
12. Frozen green beans, butter	48		65*
13. Frozen green peas, butter	48		48
14. Dehydrofrozen peas	51	0.04	61
15. Crab and cheese sauce	48	0.04	57
	87	0.05	60*
	81	0.075	61*
16. Crab cakes	20	0.075	65
	32	0.15	75**
17. Goose liver paste	32	0.10	46
	32	0.15	57
	32	0.20	71*

[1] The order of presenting products as randomized for products 1–13. After these products were tested by the original panel, additional panelists were selected, and they together with members of the original panel re-evaluated five products: 1, 2, 3, 5, and 7. Since the results were similar to those of the first series, the combined results for the two tests are shown in the table. The order of presenting products containing different glutamate levels was randomized for products 15–17.

[2] Glutamate levels corresponding to the different abilities of panel members to detect glutamate (determined in preliminary tests) were used in products 1 to 13. The duo-trio test was used; pairs of samples, with and without glutamate, were compared directly with a sample containing no glutamate. Higher levels of glutamate used in products 14 to 17 were indicated from preliminary tests showing inability of panel to detect glutamate at lower levels.

[3] Three asterisks, two, and one indicate respectively 0.1, 1.0, and 5.0% levels of probability.

easily be added to them at required levels, they represent considerably different levels of over-all flavor, and they are of commercial interest. For similar reasons cream of chicken soup, pork sausage, and liver paste were selected for tests of the effect of seasoning level; cream of chicken soup for tests of thickening level; and chicken liver paste for tests of fat level. The thickening and fat levels were chosen to represent relatively high and low levels that might be used in preparing these foods.

In chicken broth and in turkey a la king containing two levels of NaCl, two to three times the amounts of glutamate needed for detection at the lower NaCl level were needed for approximately equivalent detection at the higher NaCl level. However, the one level of glutamate tested in cream of chicken soup was detected equally well at two salt levels, and a relatively high level of glutamate was not detected at either of two salt levels in liver paste (Table 4).

Reducing the seasoning level in the cream of chicken soup and liver paste did not increase the ease of detection of added glutamate in these products. A 7-fold difference in seasoning level did not affect detection of glutamate in pork sausage. Increasing the thickening agent made glutamate detection easier in cream of chicken soup. A 7-fold difference in fat level did not affect glutamate detection in chicken liver paste.

The results obtained with variation in level of the thickening agent illustrate the complicated interrelationships of the factors comprising flavors. Contrary to expectations, glutamate was more difficult to detect in the thin soup than in the very thick soup. Comments of the judges indicated that other seasonings were much more noticeable in the thin soup, possibly objectionably so.

An additional test was made to verify this impression. Three soups were presented; a thick soup and a thin soup with equal seasonings (the level of the first test), and a thin soup containing half the above level of seasoning. The judges were asked to rank the 3 samples in order of intensity of seasoning. The 9 judges correctly ranked the two thin soups containing *different* seasoning levels. Eight of these 9 judges, however, ranked the thin soup higher in intensity of seasoning than the thick soup of *identical* seasoning level, indicating that the thickening did mask some of the seasoning effect. Thus, varying the thickening agent may have had its effect on glutamate detection in an indirect manner by changing the *apparent* level of seasonings that were actually at the same level. Results on pork sausage, in which a 7-fold increase in seasoning level did not interfere with glutamate detection, seem contradictory to the above theory. However, in the sausage the panel did not find even the highest seasoning level inappropriate (or objectionable) and much higher levels would probably be needed for interference with glutamate detection.

B. Relation between inherent glutamate levels in foods and detection of added glutamate. A comparison of the ease with which added glutamate is detected in foods (Tables 3 and 4) and the natural glutamate content of these foods (Table 5) indicates a striking relationship. Foods in which glutamate is readily detected, such as chicken broth, cream of chicken soup, and pork sausage, have a relatively low natural glutamate content (0.01–0.02). Those in which it is not readily detected, such as poultry liver paste and frozen peas, have a relatively high glutamate content (0.19–0.36). Natural glutamate content, therefore, appears to be the most reasonable basis yet considered for recommending levels for glutamate addition.

Lower glutamate content probably accounted for most of the improvement in detection of glutamate in the particular sample of dehydrofrozen peas used (0.05% glutamate) compared to the frozen peas used (0.34% glutamate). However, added glutamate was more difficult to detect in the dehydrofrozen peas, beans, and crab products than might be expected from knowledge of their inherent glutamate content. Lack of homogeneity and difficulty in incorporating glutamate uniformly in the discrete particles do not appear to explain the discrepancy completely, as indicated by the following: (1) added glutamate was detected as readily in broth with added diced celery and rice (Item 8, Table 3) as in the blended product (Item 9), (2) in dehydrofrozen peas containing approximately 0.19% glutamate, glutamate additions of 0.10% and 0.15% were not detected to any extent greater than

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TABLE 4

Influence of NaCl level, thickening agent, fat content, and seasoning level on detectability of glutamate in food products

Product	Total judgments on each comparison	Added glutamate %	Other additives	Per cent detection of added glutamate with each level (%) of other additives[1]		
			NaCl	0.50		0.75
Chicken broth	48	0.05		90		85
		0.10		100		94
		0.25		....		96
			NaCl	0.75		1.00
Turkey a la king	48	0.05		75		....
		0.10		77		71
		0.15		92		75
		0.25		....		75
			NaCl	0.40		0.80
Cream of chicken soup	56, 58	0.04		85		82
			NaCl	0.50		1.00
Chicken liver paste	52	0.20		50		48
			Seasonings, incl. NaCl	0.46		0.92
Cream of chicken soup	50, 56	0.04		76		82
			Seasonings, incl. NaCl	0.74		1.47
Turkey-chicken liver paste	52, 58	0.20		50		48
			Seasonings	0.12	0.46	0.82
Pork sausage	54, 52, 52	0.04		67	56	71
			Thickening	2.90		11.20
Cream of chicken soup	58, 60	0.02–0.04[2]		71		92
			Fat	4.0		27.0
Chicken liver paste	42, 48	0.20		62		60

[1] All results except those for the liver pastes show statistically significant detection of glutamate at the 1% level of probability or less.
[2] In this product a single glutamate level, either 0.02 or 0.04%, was used for each panel member depending on his ability to detect it as determined in preliminary tests. Different glutamate levels used for different products were those required for detection at significant levels in preliminary tests of the products.

TABLE 5

Comparison of glutamate levels recommended for addition and levels occurring in foods

Product	Levels industry recommends to add (8, 9)	Free L-glutamatic acid in foods			
		Determined by Hac, Long, and Blish (8)		Determined in this study	
		Canned[1]	Cooked fresh[2]	Canned[1]	Cooked fresh or frozen[1]
	%	%	%	%	%
Carrots	0.25				0.16
Peas	0.25	0.12	0.16–.17	0.15	0.34
					0.05 (dehydro frozen)
Asparagus	0.20	0.05–.06	0.04		
Mushrooms	0.20	0.21–.23	0.13–.14	0.04–.06	0.11
Spinach	0.20	0.02			0.02
Corn, whole	0.20	0.04	0.05	0.06	0.10
Poultry liver paste	0.18				0.19
Clam	0.15	0.09–.10			0.05
Crab	0.15	0.06			0.04
Lima beans	0.15	0.02			0.06
Pork sausage	0.15		0.01–.02		0.02
Snap beans	0.15	0.01	0.02	0.01	
Shrimp	0.15				0.13
Tomatoes	0.15			0.18	0.21 (raw)
Chicken, boned	0.12	0.02–.04			
Tuna	0.12	0.02		0.01	
Potatoes, new	0.10	0.04	0.05		
Tomato sauce				0.23	
Tomato catsup				0.29	
Tomato paste				0.54	
Chicken broth					0.02
Cheese sauce					0.08
Crab cakes					0.09

[1] Drained weight basis.
[2] Raw weight basis.

that expected by chance whether the peas were served whole or as a blended puree.

The natural content of free L-glutamic acid in various foods, its variation with stage of maturity of corn, and its loss on refrigerator storage of peas were determined by Hac, Long, and Blish *(8)*. This information has only been used as the basis for the recommendation that glutamate be added to restore "flavor losses during storage prior to processing" *(1)*. However, the present study indicates that information on L-glutamic acid content of foods could be useful as a means of indicating the probable level of glutamate addition required for effectiveness. A comparison of levels of glutamate recommended by the Glutamate Manufacturers' Technical Committee *(1, 2)* and levels found in foods shows that relatively high levels (0.25 and 0.18%) are recommended not only for peas and poultry liver paste (Table 5), which have a high natural glutamate content, but also for spinach containing 0.02%; asparagus, 0.04–0.06%; and corn, 0.04–0.10% glutamate. The usually recommended level of 0.15% is recommended for products whose natural glutamate content ranges from 0.01 to 0.18%. Evidently, natural glutamate has not been the basis for recommending levels of glutamate addition. However, the fact that a wide variety of foods do have a low natural glutamate content has apparently made the same level of supplementation reasonable for many foods. Currently recommended levels of addition might well be re-examined in the light of the relationship between natural glutamate content and detection of added amounts.

C. The effect of salt on consumer preference for foods with added glutamate. The consumer preference tests comparing paired samples, all containing a base level of NaCl, one sample of each pair supplemented with glutamate (0.15 to 0.40%), the other supplemented with NaCl (0 to 0.3%), showed preferences for the glutamate-supplemented samples ranging from no preference (50%) to 72% (Table 6). In no case was a NaCl supplement preferred to a glutamate supplement. The extent of preference for the glutamate-containing sample was apparently influenced both by the product and the NaCl level. Many persons testing beans considered the samples with the higher NaCl levels too salty, while those comparing broths considered the lower NaCl levels too bland. The writers consider that the extent of preference for the glutamate-containing sample probably decreases somewhat as the sample without glutamate approaches the optimum acceptable NaCl level.

Glutamate was detected less readily when samples were presented singly, broth alternating with a la king, than when two samples of the same food, with and without glutamate, were presented for direct comparison (Table 7). More than 10 times the amount of glutamate needed for detection in side-by-side comparisons was needed for detection in the single sample test in three of the four product-NaCl comparisons.

Although this study was conducted with the panel selected for its ability to detect glutamate at low concentrations, it is included in this discussion of consumer tests because it seems reasonable that consumers would react in a similar manner to samples presented under the two conditions. A greater difference between samples would undoubtedly be required for a distinct preference judgment by consumer panels if samples were not presented side-by-side. This would apply whether the question involved glutamate or

TABLE 6

Effect of different levels of NaCl and glutamate on preference for chicken broth, turkey a la king, pork sausage and green beans

Product	Sample A compared with samples B			Preference for sample with added glutamate
	Additions to sample A		Addition to sample B	
	NaCl	Glutamate	NaCl	
	%	%	%	%
Chicken broth	0.65	0.15	0.65	72
			0.75	62
			0.85	60
			0.95	72
	0.65	0.25	0.65	82
			0.75	65
			0.85	66
			0.95	61
	0.75	0.15	0.85	70
			0.95	70
Pork Sausage	1.0	0.15	1.0	70
			1.1	53
			1.2	50
			1.3	51
	1.0	0.25	1.0	60
			1.1	54
			1.2	74
			1.3	52
Turkey a la king	0.83	0.27	0.83	62
	0.83	0.40	0.83	64
Green beans (canned)	0.80	0.15	0.80	60
			0.85	60
			0.90	64
			1.00	72

TABLE 7

Influence of test conditions on detectability of glutamate

Product	Added NaCl	Added glutamate	Detection of samples containing added glutamate[1]	
			Duo-trio test[2]	Single sample test[3]
	%	%	%	%
Chicken broth	0.50	0.05	90	....
		0.10	100	....
		0.25	....	68
		0.50	....	83
Chicken broth	0.75	0.05	85	....
		0.10	94	....
		0.25	96	68
		0.50	....	75
Turkey a la king	0.75	0.05	75	....
		0.10	77	....
		0.15	92	....
		0.25	....	50
		0.50	....	60
Turkey a la king	1.00	0.10	71	....
		0.15	75	....
		0.25	75	35
		0.50	....	65

[1] Per cent detection out of a possible 48 judgments. Per cent required for statistical significance: 5% level of probability, 65%; 1% level of probability, 69%; 0.1% level of probability, 75%.

[2] Pairs of samples, with and without glutamate (one product, one salt level) compared directly with control sample containing no glutamate.

[3] Single sample, alternating broth and a la king, presented for judgment on presence of glutamate after control samples of each product containing no glutamate were tasted and removed.

any other flavor difference. Consumer tests based only on side-by-side comparisons may be misleading as an index of whether the preference would remain under normal conditions of eating.

SUMMARY OF RESULTS AND CONCLUSIONS

The glutamate ion has a specific flavor effect that is more readily detected than the chloride ion when NaCl and glutamate are added at approximately equal sodium concentrations to chicken broth containing normal amounts of NaCl. The panel selected for acuity to glutamate readily (95% of possible judgments) detected glutamate added to unseasoned chicken broth at levels ranging from 0.015 to 0.04%. Addition of thickenings, fat, and seasonings interfered only slightly with detection of the above levels of glutamate. The added glutamate was less readily detected in certain foods such as peas and liver paste than in others, such as pork sausage, turkey a la king, or the thickened chicken broth. Glutamate was less readily detected in chicken broth or turkey a la king containing the higher of two levels of NaCl, but limited tests on cream of chicken broth and liver paste showed no effect of NaCl level within reasonable levels of variation. However, high levels of added thickenings, fat, or seasonings did not interfere with detection of added glutamate to any greater extent than did low levels. In fact, a high level of flour added to a highly seasoned broth made detection of added glutamate easier, probably because it masked some of the other seasonings. The ease of detecting added glutamate is not greatly influenced by variation in levels of thickening agent, fat content, or seasonings that would normally be encountered in foods.

Added glutamate was much more difficult to detect in foods normally containing very high levels of glutamate than in those containing very low levels of glutamate. The glutamate content of the foods must be considered in developing recommendations for levels of added glutamate. Foods with very high glutamate content require considerably more added glutamate than foods with very low glutamate content to exhibit a demonstrable change in flavor.

The extent of consumer preference for glutamate-containing samples did not vary in a consistent manner with NaCl level, but it is suggested that the preference decreases somewhat as the optimum acceptable NaCl level is approached. This level, of course, varies for different foods and individuals. In the foods tested, the preference for those with added glutamate either equalled or exceeded preference for those without added glutamate.

The difference in performance of a trained panel on a paired comparison and a single sample test suggests that consumer tests of preference based on samples compared directly may have limited applicability under normal eating conditions.

Acknowledgment

The contributions of members of the Glutamate Manufacturers' Technical Committee, of our colleagues, of the Langfield Company, and of Owens-Illinois are acknowledged in detail in the second part of this paper, which follows.

LITERATURE CITED

1. Anon. The value of glutamate in processed foods. Glutamate Manufacturers' Technical Committee.
2. Anon. The value of glutamate in processed meat and poultry. Glutamate Manufacturers' Technical Committee.
3. Cairncross, S. E. The effect of monosodium glutamate on food flavor. In *Monosodium Glutamate, a Symposium.* Quartermaster Food and Container Institute and Associates, Food and Container Institute, Chicago. March, 1948. p. 32–38.
4. Crocker, E. C. Meat flavor and observations on the taste of glutamate and other amino acids. *Ibid.*, p. 25–31.
5. Fellers, C. R. The use of monosodium glutamate in sea food products. *Ibid.*, p. 44–48.
6. Foster, D. Taste testing methodology concerning glutamate. In *Monosodium Glutamate, a Second Symposium.* Research and Development Associates, Food and Container Institute, Chicago, September, 1955. p. 38–46.
7. Galvin, S. L. The taste of monosodium glutamate and other amino acid salts in dilute solutions. In *Monosodium Glutamate, a Symposium, op. cit.* p. 39–44.
8. Hac, L. R., Long, M. L., and Blish, M. J. The occurrence of free L-glutamic acid in various foods. *Food Technol.*, 3, 351–354 (1949).
9. Lockhart, E. E., and Gainer, J. M. Effect of monosodium glutamate on taste of pure sucrose and sodium chloride. *Food Research*, 15, 459–464 (1950).
10. Mosel, J. N., and Kantrowitz, G. The effect of monosodium glutamate on acuity to the primary tastes. *Am. J. Psychol.*, 65, 570–573 (1952).
11. Nair, J. H. Evaluation of glutamate in food specialties. In *Monosodium Glutamate, a Symposium. op. cit.* p. 48–53.
12. Najjar, V. Studies on L-glutamic acid decarboxylase from *Escherichia coli*. *J. Biol. Chem.*, 206, 215–219 (1954).
13. Norton, K. B., Tressler, D. K., and Farkas, L. D. The use of monosodium glutamate in frozen foods. *Food Technol.*, 6, 405–411 (1952).
14. Rogers, C. J., Mills, P. A., and Stewart, G. F. Incorporation and distribution of monosodium glutamate in chicken meat. *Food Technol.*, 10, 299–302 (1956).
15. Sjöström, L. B., Cairncross, S. E., and Caul, J. F. Effect of glutamate on the flavor and odor of foods. In *Monosodium Glutamate, a Second Symposium. op. cit.* p. 31–38.

Monosodium Glutamate Studies. II.

Evaluation of a Possible Flavor Stabilizing Effect of Glutamate in Frozen Foods and of the Stability of Glutamate to Commercial Canning Process

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USE OF GLUTAMATE in processed foods has raised questions concerning its stabilizing or antioxidant effect reported for frozen foods and its stability to processing conditions encountered in canned foods. It is generally assumed that glutamate is not altered in the canning process, but sufficient evidence supporting this view has been lacking. Critical analysis of conflicting published reports on whether monosodium glutamate has a flavor stabilizing effect on frozen foods has failed to resolve the question. Of three studies on frozen pork sausage, two *(7, 11)* report that glutamate has some antioxidant properties and another *(10)* indicates a possible prooxidant effect. The first study also reported an antioxidant effect on frozen poultry.

Poultry was selected for further study because of the authors' interest and previous studies on its stability under varying conditions. Cooked poultry products in addition to raw frozen poultry were included because of the growing importance of "convenience" foods, the lesser stability of cooked poultry products *(6)*, and the ease with which glutamate could be incorporated into them. Pork sausage was selected because of the conflicting reports from previous studies, because it was expected to develop off-flavors readily in frozen storage, and because glutamate could be incorporated uniformly.

One problem encountered in analysis of the published studies is that panel *preference* has not always been clearly distinguished from retardation of off-flavor development. This situation has occurred when samples with and without added glutamate are compared directly, and results showed an initial preference as well as a preference after storage for the samples to which glutamate has been added. Obviously, such results cannot be interpreted as an indication that glutamate has a stabilizing effect in frozen storage, since they may simply indicate that this panel preferred foods with glutamate added, in the presence as well as in the absence of a storage induced off-flavor. With tests of this type Norton *et al (11)* reported that poultry and other meats and fish "retained their original high quality for longer periods in freezing storage" when glutamate was used than when not used. The panel, consisting of 5 or 6 persons, apparently made a single comparison of samples with and without added glutamate at each test period. Comments indicating that rancid flavor developed in the samples without glutamate encouraged the opinion that glutamate has some antioxidant properties, but chemical tests to provide supporting evidence were not made.

In a study by Kemp *(7)* a panel of 8 to 14 members found no differences in palatability among pork sausage samples stored less than 4 months at 0° F with and without added seasonings and glutamate (0.1 and 0.3%). Samples stored 4 to 12 months with seasonings but no glutamate were consistently rated lower in palatability than those with neither seasonings nor glutamate, and those with both seasonings and glutamate. When judged for palatability, all samples had added seasonings (to three it was added before and to the other three it was added after storage). Some undesirable palatability change during storage of the seasoned samples stored without glutamate is indicated which either did not occur or was not detected in the seasoned samples stored with glutamate and in the unseasoned samples stored with no glutamate. No difference was found between samples containing the two levels of glutamate. No chemical tests were conducted. A darkening in color was reported in all seasoned samples (with or without glutamate) during storage.

Neill and Page *(10)* tested raw and cooked unseasoned sausage containing 0, 0.10, 0.15, and 0.30% glutamate for acceptability and peroxide development after storage at −10° F. Acceptability ratings showed an original preference for glutamate-containing samples that was unaffected by storage for 1 year. Significant peroxide development occurred only in the raw pork series after 18 months' storage. It was slightly higher in the glutamate treated samples than in the control. This was interpreted by the authors as indicating a slight prooxidant effect of glutamate.

Addition of glutamate is recommended for a large number of foods that are to be subjected to a canning process at 240–250° F. Military specifications include glutamate for the following canned products: soups, codfish patties, turkey loaf, tuna and noodles, hamburgers, and sausage patties *(3)*. It is generally assumed that this processing treatment does not materially influence the effect of the added glutamate, but the evidence is inconclusive. Galvin *(4)* reported that in canned soups the glutamate taste is not much

[a] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

affected by the heat process—the flavor of foods changes more than glutamate. Anson *(1)* reported that the flavor of glutamate itself is not greatly influenced by processing and storage. In analyses of several fruits and vegetables prior to and following canning, Mahdi *et al (8)* found that the heat process did not decrease the level of free natural glutamic acid. The possibility that added glutamate would cause flavor changes by increasing the rate of the browning reaction has been considered by Anson *(1)* and Melnick *(9)*. This phase of the problem was not considered in the present study, as the products studied had a considerably higher water content than the 10 to 15% at which the rate of browning is normally at a maximum *(1)*.

METHODS

Two types of panels were required for the sensory tests used because of the differences in objectives of these studies. For the test of effectiveness of glutamate as a flavor stabilizing agent (antioxidant) in frozen foods, the judges were selected for their ability to detect the stale and rancid off-flavors that may develop in frozen poultry and sausage products. For the test of the stability of glutamate to the canning process, the judges were those selected in a previously reported study for their ability to detect small flavor differences between products with and without added glutamate.

Sensory tests for effectiveness of glutamate as a flavor stabilizing agent in frozen foods. These sensory tests were based on the extent to which the panel could detect off-flavors in foods stored at 10° or 20° F. in the presence and in the absence of glutamate. No direct comparison of samples with and without glutamate was made; thus questions of preference or acceptability were eliminated.

The general plan for testing was a comparison between samples stored at 10° or 20° F and controls held at −30° F after various storage periods. Samples without glutamate held at elevated temperatures and at −30° F were compared directly, as were samples with glutamate held at elevated temperatures and at −30° F. Judges were asked to indicate which of each pair of coded samples had more off-flavor. They were also asked to comment on the type of off-flavor (staleness or rancidity) as an aid in interpreting the importance of the flavor change.

Extent of detection of off-flavors in the foods without glutamate held at elevated temperatures was compared with the extent of detection of off-flavors in foods with glutamate to determine whether off-flavors developed more rapidly or were detected more readily in the products that did not contain glutamate. If off-flavors were distinguished more readily in the products with no glutamate than in those with glutamate, two conclusions would have been possible. Either glutamate prevented the chemical changes responsible for off-flavor development or it masked changes which occurred. If off-flavors were distinguished to approximately the same extent, it could be concluded that glutamate did not show a stabilizing effect on flavor under the conditions of this experiment.

The panel of judges evaluated each set of samples 4 or 5 times at each storage period. Each comparison is thus based on at least 32 judgments. Samples compared were from the same production lots. The order of presenting pairs containing no glutamate and pairs containing glutamate was randomized at each storage period.

Sensory tests for stability of glutamate to the canning process. For the test of stability of glutamate to the canning process, samples of the broths to which glutamate was added before and after processing were evaluated by the panel selected for its ability to detect small differences in flavor, using the duo-trio test described in the previous paper *(5)*. The control sample was the sample with glutamate added before processing. Coded samples containing glutamate added before and after processing were presented with the control. The panel was asked to indicate which of the two coded samples was like the control. Samples were randomized and tests were replicated as in the previous tests.

Sample preparation for frozen food tests. *Fried Chicken.* Sixty chickens weighing approximately 2 lb (ready-to-cook) were cut into the following pieces: wing, breast, thigh (including part of backbone), and drumstick. Pieces were rolled in a dredge consisting of flour or a mixture of flour and an amount of glutamate needed to yield a concentration of 0.15% or 0.35% glutamate in the uncooked product (chicken, dredge, and batter). The amount of glutamate needed was based on preliminary experiments to determine the average pickup of dredge and batter by chicken parts of this weight. The dredged chicken parts were dipped in a batter of the following composition:

Ingredient	Per cent
Flour	28
Shortening	2.5
Milk	54.6
Salt	1.4
Eggs	13.5

The chicken was transferred rapidly to a deep fat fryer containing peanut oil and fried for 10 min at 145° C (293° F), keeping chicken below the fat level. One half of each chicken was stored at 10° F in a polyethylene bag placed in a carton, and the other half was stored at −30° F in a N_2 atmosphere.

In preliminary experiments, in which glutamate was added to the batter, birds with glutamate showed more browning during cooking than those to which glutamate was not added. Therefore, glutamate was added with the dredge, since increased browning did not occur when the glutamate was applied to the layer beneath the crust.

Turkey. Sixty small Beltsville turkeys were eviscerated at the laboratory and injected while warm with solutions containing gelatin and glutamate as recommended by Ellis *(2)*. They were divided into 4 groups of 15 each. One group received no injection, one a 2.5% gelatin solution, two a solution containing 2.5% gelatin and glutamate. The solutions were injected through a hypodermic needle connected to a pipetting machine, 5 ml per injection, with enough injections (25–30) to give approximate concentrations of 0.15 and 0.35% glutamate in the last two groups, distributed as evenly as possible in the breast, thigh, and leg. Birds were chilled in slush ice in polyethylene bags, frozen, sawed in half, and repackaged for storage. Half of each was wrapped in cellophane for storage at 10° F; the other half was packed in Cry-o-vac and held at −30° F as a control.

Turkey a la king was prepared according to the method described in the previous paper *(5)*. The product was divided into three parts, and glutamate added to two of these to give concentrations of 0.15 and 0.35%. Experimental samples were stored in MSAT cellophane bags in cartons at 10° F and control samples at −30° F in sealed cans in a N_2 atmosphere.

Pork sausage was prepared according to the method described in the previous paper. The pork trimmings were divided into 3 parts. NaCl (1%), the seasonings, and glutamate (for the 2 parts containing 0.15 and 0.35% glutamate) were added before grinding and mixing. For lot 1, sausage was divided into ½-lb portions, packaged in cellophane or canned as required, and frozen at −30° F. The packaged samples were stored at 10° F. This sausage contained 60% fat.

A second lot of sausage was prepared by the above method. Experimental samples were packed loosely in cans with air in the headspace approximately equal to the volume of the sausage, hermetically sealed, and stored at 20° F. Control samples were canned, N_2 packed, and stored at −30° F. This lot of sausage contained 50% fat.

Sample preparation for canning tests. *Chicken broth, cream of chicken soup,* and *green snap beans* were heat processed with and without added glutamate. The broth and cream of chicken soup were prepared as described previously with two levels of glutamate, 0.10 and 0.25%. The NaCl level in the broth was 0.75% and in the cream of chicken soup 1.125%. They were processed in No. 303 glass jars, 400 g per jar, at 240° F for 25 min. A second lot of the cream of chicken soup was subse-

quently prepared with a lower NaCl content (0.75%) to guard against the possibility that the relatively high salt level in the first batch might have masked any slight flavor differences. The second batch was processed in 403 x 612 cans, approximately 1,170 g per can at 240° F for 50 min. The green beans were purchased fresh from a local supermarket. After washing, ends were removed and beans were cut into 2 inch pieces, blanched at 180° F for 1½ min, cooled, packed in 209 x 313 cans to which brine containing NaCl and glutamate was added as required. They were processed at 240° F for 20 min.

Chemical tests. Tests for peroxide development were made on the frozen foods at each temperature at intervals of 2 weeks or more to indicate whether chemical changes occurred in either the meat and skin (with coating) of the fried chicken, in cooked turkey meat and turkey a la king, and in raw and cooked pork sausage. The method used has been described by Pool *et al (12)*.

Glutamate determinations on the broth and cream of chicken soup were made on samples to which glutamate was added after canning as well as before canning and on the bean samples to which glutamate was added before canning by the enzymatic decarboxylation method described in Part I of this paper *(5)*.

RESULTS

Possible flavor stabilizing effects of glutamate in frozen foods. Monosodium glutamate, added in concentrations of 0.15 and 0.35% of the product weight had no beneficial effect in preventing or masking off flavor development in frozen fried chicken stored at 10° F for 4 months in turkey a la king or raw turkey stored at 10° F for 9 months, or in pork sausage stored at 10 and 20° F for 4 months. Flavor differences between controls held at −30° F and samples held at 10 or 20° F were detected approximately equally in samples with and in samples without glutamate (Table 1). Flavor testing was discontinued after changes were consistently recognized by the judges. Comments of the judges indicated that staleness developed to some extent in all of the products at the elevated temperatures and that rancidity developed in the fried chicken at 10° F and pork sausage at 20° F (Table 2). Comments for samples containing the two levels of glutamate are reported together since they were very similar. Also, comments for all storage periods have been combined for the sake of simplicity although there were a few more adverse comments on samples stored two months or longer than those stored less than 2 months. Since a rancid type of off-flavor is considered a more serious defect than staleness, an illustration of the approximately equal distribution of comments among the 3 glutamate levels (0, 0.15, and 0.35%), for fried chicken, the product that received the most rancidity comments, has been plotted (Figure 1).

Peroxide tests were continued after flavor tests had been stopped to see whether any beneficial effect of glutamate developed with longer storage. The addition of monosodium glutamate had no effect on peroxide developments in these products at 10° F for

TABLE 1

Effect of glutamate on off-flavor development in stored frozen foods

Product and storage temperature	Storage time	Per cent judgments indicating more off-flavor in samples stored at 10° or 20° F than in controls at −30° F[1]		
		Added glutamate		
		0	0.15%	0.35%
	Mo			
Fried Chicken 10° F	1	66	69	78
	2	87	81	87
	4	97	84	87
Turkey a la king 10° F	3	63	81	63
	6	66	75	69
	9	100	78	84
Turkey 10° F	3[2]	56		
	3[3]	66	53	72
	6[2]	66		
	6[3]	69	84	56
	9[2]	58		
	9[3]	75	75	86
Pork Sausage 10° F	0.5	47	72	63
	1	75	59	63
	2	81	78	72
	4	53	59	69
Pork Sausage 20° F	1	69	31	81
	2	72	72	63
	4	78	66	75

[1] Total number of judgments, paired comparison test = 32 (all tests except turkey, 9 mo.). Per cent required for statistical significance is 69, 75, and 81 for the 5%, 1%, and 0.1% levels of probability, respectively.

Total number of judgments, turkey, 9 months only = 36. Per cent required for statistical significance is 67, 72, and 78 for the 5%, 1%, and 0.1% levels of probability, respectively.

[2] No injection of birds before freezing.

[3] Gelatin injected with or without glutamate as indicated.

TABLE 2

Adverse comments on frozen foods stored with and without glutamate addition

Product	Per cent adverse comments by panel[1]			
	−30° F controls		Stored samples	
	Glutamate		Glutamate	
	−	+	−	+
Staleness				
Fried chicken +10° F	3	4	36	25
Turkey +10° F	8	4	12	13
Pork Sausage +10° F	3	4	9	14
Pork Sausage +20° F	6	5	10	11
Rancidity				
Fried chicken +10° F	3	4	19	21
Turkey +10° F	0	0	2	2
Pork Sausage +10° F	1	0	2	3
Pork Sausage +20° F	4	4	7	13

[1] Total tastings for each sample ranged from 96 to 128 for the unsupplemented samples and from 192 to 256 for the glutamate samples.

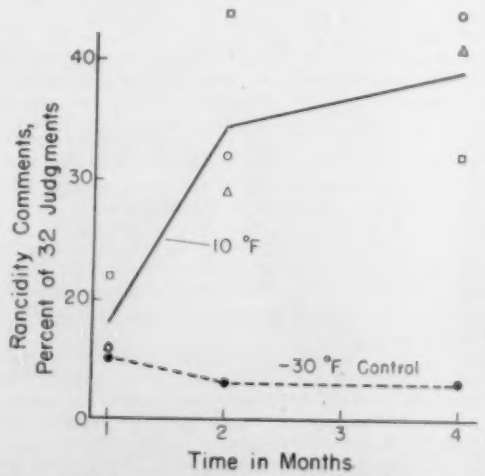

Figure 1. Similarity of rancid flavor development in frozen fried chicken with and without added monosodium glutamate. Triangles, circles, and squares represent no glutamate, 0.15%, and 0.35% glutamate, respectively.

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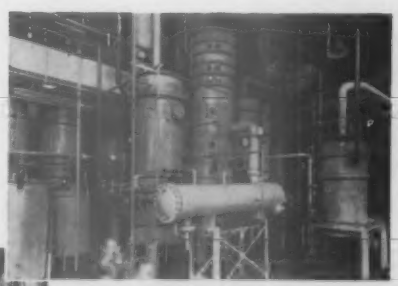

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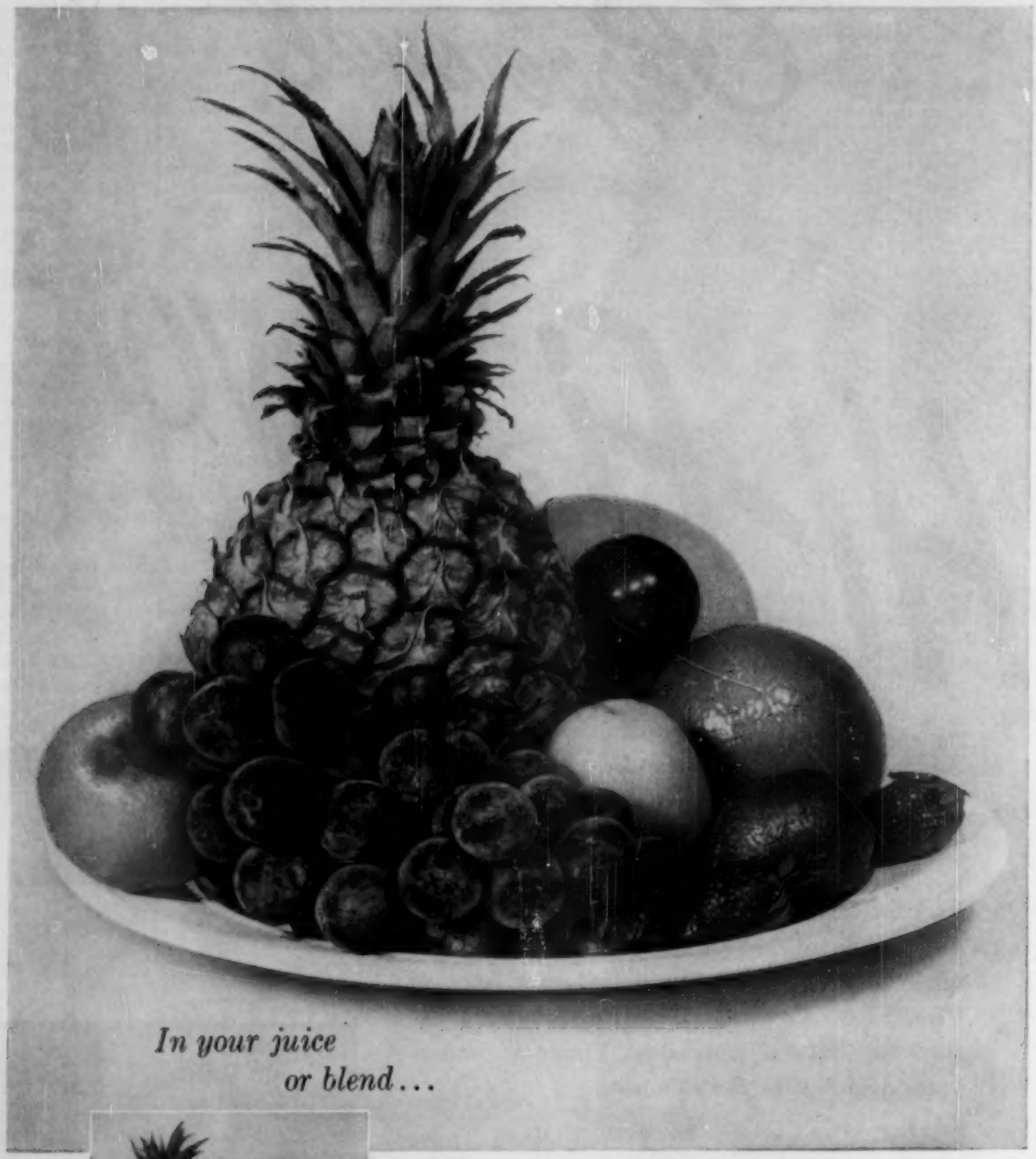

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the following storage periods: fried chicken, 1 year; turkey a la king, 15 months; raw turkey, 9 months; pork sausage, 9 months; and in pork sausage at 20° F for 6 months. The peroxide values for all products were relatively low even after the longest storage periods. Increases in peroxide values of the above products during the indicated storage times were as follows: fried chicken, 6 to 11; turkey a la king, 8 to 12; raw turkey, 5 to 7; pork sausage at 10° F, 3 to 10; pork sausage at 20° F, 2 to 6, expressed in meq/kg. Values for pork sausage stored at 20° F include glutamate levels of 1 and 2% in addition to the 0, 0.15, and 0.35% levels used in the other products. Peroxide values are shown separately for the three glutamate levels used in fried chicken (Figure 2) to illustrate the similarity among values found in all products.

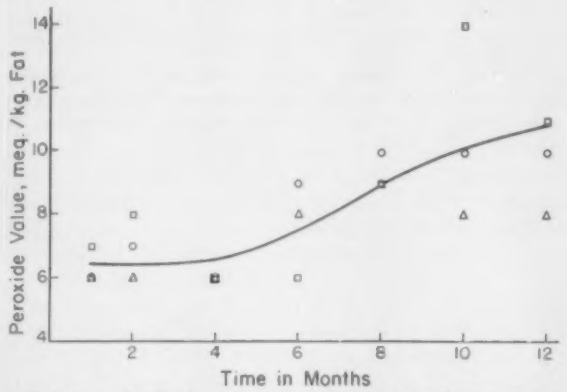

Figure 2. Similarity of increase in peroxide values in frozen fried chicken at 10° F, with and without added monosodium glutamate. Triangles, circles, and squares represent no glutamate, 0.15% glutamate, and 0.35% glutamate, respectively.

No difference was observed in this study in sausage color related to glutamate level, contrary to a previous report *(11)*.

Stability of glutamate to heat processing. Glutamate determinations by the enzymatic decarboxylation method described in the previous paper *(7)* showed no loss in added glutamate in chicken broth, cream of chicken soup, or green beans due to commercial canning conditions (Table 3).

TABLE 3

Effect of commercial canning conditions on glutamate retention

Product	Added glutamate	Monosodium glutamate found[1]		
		Glutamate added		
		Before processing		After processing
	%	%		%
Chicken Broth	0.10	0.126		0.123
	0.25	0.272		0.269
Cream of Chicken Soup	None	0.020		
	0.10	0.116		0.122
	0.25	0.275		0.263
		Beans	Brine	
Green Beans	None	0.009	0.005	.....
	0.15	0.117	0.131	.....
	0.30	0.266	0.296	.....

[1] Values are averages of three or more determinations per can on 2 to 6 cans per product.

TABLE 4

Effect of adding glutamate before or after canning on flavor of chicken broth and cream of chicken soup

Product	Concentration of added glutamate	Number of judgments[2]	Judgments identifying sample with glutamate added before canning[1]
	%		%
Chicken broth	0.10	24	25
	0.25	21	52
Chicken Soup (cream of)	0.10	126	44
	0.25	117	49

[1] Duo-trio test judges were asked to identify sample in each pair which was identical to control sample to which glutamate had been added before canning.

[2] Results are combined for the two processing runs made on cream of chicken soup.

Evaluation of chicken broth and cream of chicken soup showed that the panel of judges selected to detect small flavor differences was unable to identify the samples of these products to which glutamate was added before processing when they were compared directly with identical control samples and samples to which glutamate was added after processing (Table 4).

SUMMARY OF RESULTS AND CONCLUSIONS

Monosodium glutamate at 0.15 or 0.35% did not prevent or delay off-flavor development at 10° F in fried chicken held 4 months; turkey a la king, 9 months; raw turkey, 9 months; or pork sausage, 4 months; or in pork sausage held 4 months at 20° F. Nor did it retard peroxide development at 10° F in fried chicken held 1 year; turkey a la king, 15 months; uncooked turkey, 9 months; or pork sausage, 9 months; or pork sausage held 6 months at 20° F. The presence of glutamate neither prevented peroxide development nor did it mask the flavor changes that occurred.

No loss in glutamate content was found in chicken broth, cream of chicken soup, or green beans subjected to commercial canning conditions. No flavor differences were detected between two samples of chicken broth or cream of chicken soup prepared by adding equal amounts of glutamate before and after canning, respectively.

Since glutamate is stable to heat processing and since it does not affect the usual processing changes in the product as judged from this limited study, addition prior to canning, as is generally recommended, is indicated to assure uniform distribution, especially in heterogeneous products.

Acknowledgment

The authors wish to record here their sincere gratefulness to the members of the Glutamate Manufacturers' Technical Committee and to Dr. M. J. Blish, consultant to the Committee during part of the time, for their constructive interest, support, and advice throughout the course of this work; to Dr. M. J. Copley, Director of the Western Utilization Research and Development Division, U.S.D.A., for support and advice in the conduct of the program; to the Fruit and Vegetable Laboratory of WURDD for advice and for certain samples of vegetables; to Miss Mildred M. Boggs of that Laboratory for a critical review of the manuscripts; to Mr. J. G. Davis for consultation and valuable assistance in conducting the glutamate

injection studies on turkey; to Miss Iva V. Streeter for the peroxide determinations; to Dr. Stanley Mandeles, Mr. E. D. Ducay and Mr. Henry G. Bayne for assistance at various times in the glutamate determinations; to Mr. A. A. Klose for assistance and advice in many of the poultry flavor studies; to Mr. A. W. Langfield, Pres., The Langfield Co., Inc., for samples of frozen peas and beans; and to the Research and Packaging Division of Owens-Illinois, Mr. H. T. Griswold, Manager, for cooperation in the canning of experimental samples of chicken broth and cream of chicken soup. We are especially grateful to the many members of the Laboratory staff who served faithfully and unstintingly on the expert and consumer type taste panels and thus made this study possible.

LITERATURE CITED

1. Anson, M. L. The relation of glutamate to the browning reaction. In *Monosodium Glutamate, a Symposium.* Quartermaster Food and Container Institute and Associates, Food and Container Institute, Chicago, March, 1948, pp. 61–70.
2. Ellis, E. D. Process of treating fowl. U. S. Patent No. 2,687,961. August 31, 1954.
3. Fry, L. V. Military specifications covering the use of glutamate. In *Monosodium Glutamate, a Second Symposium.* Research and Development Associates, Food and Container Institute, Chicago. September, 1955. p. 27, 28.
4. Galvin, S. L. in discussion of article by Cairncross, S. E. Effect of monosodium glutamate on food flavor. In *Monosodium Glutamate, a Symposium. op. cit.* p. 36.
5. Hanson, H. L., Brushway, M. J., and Lineweaver, H. Monosodium glutamate studies. I. Factors affecting detection of and preferences for added glutamate in foods. *Food Technol.*, **14**, 320–327.
6. Hanson, H. L., Fletcher, L. R., and Lineweaver, H. Time-temperature tolerance of frozen foods. XVII. Frozen fried chicken. *Food Technol.*, **13**, 221–224 (1959).
7. Kemp, J. D. The use of monosodium glutamate in frozen pork sausage. *Food Technol.*, **9**, 340, 341 (1955).
8. Mahdi, A. A., Rice, A. C., and Weckel, K. G. Off-flavors in foods, formation of pyrrolidonecarboxylic acid in processed fruit and vegetable products. *J. Agr. Food Chem.*, **7**, 712–714 (1959).
9. Melnick, D. Discussion following paper by Anson, M. L. cf reference 2, above. p. 66.
10. Neill, J., and Page, L. The effect of antioxidants on frozen ground pork. *Food Technol.*, **10**, 315–319 (1956).
11. Norton, K. B., Tressler, D. K., and Farkas, L. D. The use of monosodium glutamate in frozen foods. *Food Technol.*, **6**, 405–411 (1952).
12. Pool, M. F., Hanson, H. L., and Klose, A. A. Effect of prefreezing hold time and antioxidant spray on storage stability of frozen eviscerated turkeys. *Poultry Sci.*, **29**, 347–350 (1950).

Tofu from Japanese and United States Soybeans[a]

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(Manuscript received February 9, 1960)

Annual export of United States soybeans to Japan has risen from practically nothing after War II to more than 35 million bushels in the 1958–59 crop year. This amount is more than double present Japanese production, but still their supplies are far short of their needs. Most of the U. S. beans exported to Japan are processed for oil and meal that are used for making food products. Estimates based on a survey in 1957 *(4)* indicate that in making certain traditional foods, such as miso, tofu, and natto, at least 25 million bushels of whole soybeans were used and the Japanese indicated they could and wish to use more *(8)*. Thus, further expansion of U. S. exports to Japan appears possible if ways and means of making more acceptable miso and tofu from United States soybeans can be found. How tofu, or bean curd, and other Oriental foods are made from soybeans in Japan, Korea, and China has been described previously *(3, 4)*.

Tofu (composed principally of protein and oil) is made by precipitation of the curd with a calcium salt from a hot water extract of whole soybeans. Fresh commercial tofu, which is sold in the form of a wet cake, has the approximate composition of 6% protein, 3.5% fat, 1.9% carbohydrates, 0.6% ash, and 88% water *(6)*. Good tofu has a very bland taste and is white or a very pale yellow in color. In the home it is cut into small pieces and served in soup; it can also

[a] Report of work done in collaboration with USDA Foreign Agricultural Service and American Soybean Association. The Japanese American Soybean Institute furnished samples of Japanese products needed for this work.

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be fried in deep fat or prepared in other ways. Although in its present form it is not expected that Japanese tofu will find a place in the U. S. food market, its composition and simple method of production suggest that more highly mechanized procedures could be found for making a low-cost, protein-oil concentrate which may find a place as a food supplement in America.

In an investigation made in Japan *(4)* in 1957, we were told by the Japanese that our soybeans are not as satisfactory for making their traditional foods as their domestic beans. They stated that food products prepared from U. S. soybeans are not equal in color, texture, flavor, and other properties to foods made from Japanese beans. The present investigation is part of a program intended to find methods of improving the use of U. S. soybeans in making traditional Japanese foods as one means of increasing soybean exports.

Japan is the largest single customer for our soybeans and since her present and future needs far exceed current consumption, Japan represents an increasing market for one of our important agricultural commodities. Moreover, increased production of soybeans could play a vital part in solving the surplus problem. Even though soybeans have not been classified as surplus, they are grown on millions of acres in the Mississippi Valley which otherwise would be used for crops that are surplus.

Soybean seed stock, used to breed varieties later introduced into commercial production in the United States in the early 1930's, was obtained from the Orient. Present differences between U. S. and Japanese beans appear to be the result of the extensive soybean breeding program in this country. Our breeding program has modified soybean composition and properties to meet the need of our farmers and oil mill processors, rather than the need of food processors here or in the Orient. This modification has created technical problems in soybean export markets when the beans are sold for food. Although the differences between U. S. and Japanese beans are not large, they are enough to be noticeable in food products.

More than 35 varieties of soybeans *(5)* are grown from Minnesota to Florida. The flowering and yield of soybeans depend more on length of daylight than do most crops. This light sensitivity, as well as other factors that are influenced by location, explains the need for the many varieties. In the soybean breeding program, new and improved varieties are developed each year for replacing one or more of the older types; thus the list of recommended varieties constantly changes.

Soybean varieties vary in protein and oil content, rate of cooking, flavor, color of seed coat and of cotyledon, size of seed, and other physical properties. Because of these wide differences, it appeared likely that some of the U. S. varieties might meet Japanese requirements.

The primary objective of this work was to compare U. S. and Japanese soybean varieties for making tofu and to determine which U. S. varieties make a satisfactory product. When such varieties are known to U. S. exporters and Japanese importers, more soybeans may be exported to Japan "identity preserved" at some increase in cost over the U. S. No. 2 yellow beans. Limited time permitted a survey of only 15 U. S. and 5 Japanese varieties, but it is hoped this work will continue in Japan. One variety from Punjab, India, was included in the investigation.

METHODS

The procedure and equipment for making tofu followed closely the commercial method used in Japan *(4)*. The pilot plant equipment consisted of an emery-coated grinder, 40-quart pressure cooker containing a steam coil, modified cider press, filter boxes, and water tank. The grinder,[4] imported from Japan, was designed for wet grinding of soybeans.

Briefly, 1.8 kg of soybeans were washed and soaked overnight in water and ground while adding a small stream of water. The mash was placed in the pressure cooker and water added to make a ratio of water to beans of 10: 1 on the basis of the original beans. The mash was cooked 30 min starting at room temperature; in this period an approximate gage pressure of 4 lb was reached. When the cooking was complete, the pressure in the kettle was used to force the mash through the outlet and into a coarse filter bag laid inside the press. After filtering, the milk was pressed from the residue to give a yield of approximately 16.5 kg. The milk was divided into two equal parts, cooled to 65° C, and while stirring slowly the curd was precipitated by adding to each part 25 g of powdered calcium sulfate suspended in 200 ml water.[5] Stirring was stopped as soon as the calcium sulfate was added to avoid breaking the curd. A filter cloth on a hemispherical frame was placed over the curd and as the curd settled, 300 ml of the supernatant was removed with a dipper. The curd was then transferred to wooden boxes or molds with inside dimensions of 23 cm long x 115 wide x 19.5 deep. The box, lined with a coarse filter cloth, contained small holes in its sides to drain off the water. The curd was pressed by placing over it a slotted frame-work and a 700-g weight. When draining had almost stopped, the box was placed in a tank of water, and inverted to remove the curd; the curd remained in the water about 1 hr. A cake of tofu from 1.8 kg of beans weighs in the range of 5.5 to 6.0 kg, about half the size usually made commercially. In actual practice tofu is cut into thick slices and sold while fresh.

RESULTS AND DISCUSSION

Tables 1, 2 and 3 show results of laboratory and pilot plant experiments designed to determine (a) yields of tofu from U. S. and Japanese beans, (b) relative quality of tofu from the two sources, and (c) relationship between water-soluble protein (N x 6.25) and oil content of the beans to the yield of tofu, and to the protein and oil content of the tofu.

Since the U. S. soybeans used in this work were uncomposited samples of single varieties grown in a limited area, they show a wide variation in protein and oil content. Thus, our variety values do not necessarily agree with those for composited samples of the same variety reported by the Crops Research Division, USDA *(2)*. The Japanese soybeans probably do not represent particular varieties; the names used represent the areas in which they were grown. For the limited number of uncomposited samples, the Japanese beans have a higher average protein than the U. S. beans. However, the average value for

[4] Supplied through the courtesy of the Japanese American Soybean Institute, Tokyo.

[5] According to unpublished procedures developed independently in Japan by one of the authors.

Japanese beans is affected considerably by the very high value for Kumamoto and for U. S. beans by the unusually low values for Acme and Norchief. The Kumamoto has the highest rating in Japan for making tofu. A previous report *(5)* covering a larger number of varieties shows that while wide variations in protein content of random samples of U. S. and Japanese soybeans are quite common, the average protein values for well-composited batches of beans show only small differences. The differences in composition of U. S. beans probably reflect the effect of location as much as varietal differences and *uncom-*

TABLE 1

Comparison of U. S. and Japanese soybean varieties in pilot-plant production of tofu

1	2		3	4	5	6	7	8	9	10	11	12		
Soybean variety	Soybean[1]		Protein conc. of milk in lab. 80° C ext'n[2]	Protein conc. of milk in tofu p plant	Yield of tofu[3]	Yield of tofu[4]	Yield of protein[5]	Protein in tofu[5]	Height of tofu[6]	Moisture in tofu	Hardness of tofu[7]	Quality of tofu[8]		
	Protein	Oil										Coagulation	Texture	Color
	%	%	%	%	*kg*	%	%	%	*cm*	%				
Japanese beans														
Nagano	42.2	17.4	3.27	3.27	2.64	51.8	73.5	60.0	10.5	84.1		3	3	3
					2.60	52.3	74.4		10.0	83.7	41			
Hokkaido	41.3	17.4	3.32	3.24	2.60	44.0	63.7	57.7	11.0	86.3				
					2.60	39.1	56.5		11.0	87.8	48	3	2	3
Miyagi	40.9	16.8	3.09	2.92	2.30	40.6	57.0	57.1	10.3	85.7		2	2	3
					2.38	38.8	53.8		10.3	86.8	42			
Aomori	40.6	16.9	3.07	3.12	2.50	43.0	63.0	59.0	10.5	86.1		3	2	3
					2.37	44.4	63.8		10.0	84.8	36			
Kumamoto	46.5	15.7	3.56	3.43	2.98	52.1	70.0		12.5	85.8		3	3	3
					3.18	49.1	65.8	62.2	13.3	87.5	47			
Average	42.3	16.8	3.26	3.20	5.23	45.4	64.2		11.4	85.9	43			
India	45.4	18.5	3.42	3.83	2.69	52.9	71.8		10.8	84.1		3	3	3
					2.82	52.1	70.0	61.4	11.7	85.0	45			
U. S. soybeans														
Harosoy	43.1	19.9	3.46	3.16	2.33	42.7	59.4		10.0	84.6		2	2	1
					2.55	43.2	59.8	59.8	10.3	85.8	47			
Hawkeye	43.2	18.9	3.51	3.53	2.80	46.6	66.5		11.0	86.1		2	3	1
					2.83	48.8	67.7	60.8	11.3	85.6	43			
Adams	42.3	19.9	3.26	3.24	2.78	46.8	63.3	57.3	12.0	85.9	49	1	2	2
Chippewa	43.1	20.3	3.47	3.42	2.86	53.0	70.5	57.1	12.0	84.5		2	2	1
					3.11	47.2	61.4		12.8	87.3	48			
Clark	42.4	20.6	3.28	3.32	2.92	46.1	60.0	54.6	12.0	86.8		3	2	1
					3.00	45.2	56.7		12.5	87.4	68			
Lincoln	43.0	19.5	3.45	3.22	2.58	46.6	63.0	57.7	10.0	84.8		1	1	1
					2.72	45.7	60.5		10.0	86.0	35			
Blackhawk	38.9	19.3	2.99	3.04	2.80	44.2	64.3	56.1	11.5	86.9		2	3	2
					2.67	43.7	66.5		10.7	86.3	52			
Acme	34.7	21.0	2.74	2.73	2.83	42.3	60.7	50.0	11.5	87.5		2	1	2
					2.67	42.5	62.8		11.0	86.4	65			
O. Mandarin	40.3	18.2	3.16	3.22	2.75	43.0	61.1		11.5	86.9		2	1	2
					2.65	43.7	63.0	58.0	11.3	86.2	37			
Norchief	33.2	21.2	2.52	2.56	2.95	47.5	67.0	46.3	11.0	86.5	61	2	2	1
Comet	39.1	19.3	2.84	3.08	2.55	46.1	64.5	54.7	10.5	84.9	49			
					2.44	49.0	68.7		10.5	83.2		2	1	3
Lee	43.8	20.5	3.25	3.22	3.03	46.3	60.5	56.8	12.8	87.2		3	3	3
					3.03	48.5	62.5		12.8	86.6	54			
Jackson	42.0	20.5	3.12	3.14	2.83	46.6	60.6	54.8	11.5	86.2		3	3	3
					2.83	45.8	60.0		11.5	86.5	44			
Dorman	42.3	21.2	3.15	2.99	2.95	49.1	62.6		12.0	86.1		2	2	2
					2.92	48.5	60.5	53.5	12.0	86.1	58			
Dortchsoy	38.3	22.1	2.85	2.64	2.87	42.7	57.5	51.4	11.5	87.6	78	2	2	2
Average	40.7	20.1	3.14	3.10	5.55	46.1	62.7		11.3	85.9	49			

[1] Dry basis.
[2] Per cent nitrogen extracted from full fat flakes at water-to-meal ratio of 10: 1, 80° C and 30 min extraction.
[3] From 1.8 kg soybeans.
[4] Dry basis, based on original weight of soybeans.
[5] Based on protein content of original soybeans, dry basis.
[6] Height of tofu in box indicates the relative volumes of tofu.
[7] Measured by Precision penetrometer designed for measuring softness of bread. The higher the value the softer the tofu.
[8] Visual evaluation by an experienced operator; 3—highest rating, 2—second highest, and 1—lowest rating.

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TABLE 2

Soluble protein plus oil of beans compared with yield and with protein and oil content of tofu

Variety	Sol prot + oil in beans[1]	Yield of tofu[2]	NSI[3]	Protein in tofu[4]	Oil in tofu[4]	Oil and protein in tofu[4]
	%	kg	%	%	%	%
Japanese soybeans						
Kumamoto	54.1	6.16	82.6	62.2	21.4	83.6
Hokkaido	53.9	5.20	88.3	57.7	25.5	83.2
Nagano	53.6	5.24	85.7	57.5	24.9	82.4
Aomori	51.1	4.87	83.4	58.9	27.0	85.9
Miyagi	50.8	4.69	83.1	57.1	24.7	81.8
Average				58.7	24.7	83.4
India	51.9	5.51		61.4	24.3	85.7
U. S. soybeans						
Chippewa	58.5	5.97	88.6	57.1	26.4	83.5
Harosoy	57.7	4.88	87.8	59.8	27.2	87.0
Hawkeye	57.5	5.63	89.4	60.8	27.8	88.6
Lincoln	57.3	5.30	87.9	57.7	26.5	84.2
Clark	56.6	5.92	84.8	54.6	28.2	82.8
Lee	56.4	6.06	81.9	56.8	27.5	84.3
Adams	56.0	5.36	85.2	57.3	26.7	84.0
Dorman	56.0	5.87	82.2	53.5		
Jackson	55.0	5.66	82.2	54.8	29.3	84.1
Dortchsoy	53.6	5.74	82.2	51.4	32.2	83.7
O. Mandarin	52.6	5.40	85.4	58.0	27.1	85.1
Blackhawk	51.4	5.47	82.5	56.1	29.4	85.5
Acme	50.1	5.50	84.0	50.0	31.4	81.4
Comet	49.5	4.99	77.3	54.7	28.5	83.2
Norchief	48.1	5.90	81.2	46.3	33.2	79.5
Average				55.3	28.7	84.0

[1] Computed as (protein in beans x NSI) + oil.
[2] Wet basis, from 1.8 kg of soybeans.
[3] Nitrogen solubility index or per cent soluble nitrogen at 80° C at water-to-meal ratio of 10:1.
[4] Dry basis.

posited samples should not be considered as average or typical values. The oil values for all U. S. varieties reported here and in earlier publications are higher than for Japanese beans. Uncomposited samples were used in this work because they would probably be more representative of what an individual processor might receive in Japan. Although location affects composition, we do not believe that location is as important to the quality of tofu as variety. For example, color among varieties is known to vary and color is one important factor in tofu quality.

Yield of tofu. In making tofu, oil is extracted with the protein as a stable emulsion. It was anticipated that the yield of tofu would be directly related to the sum of the water-soluble protein and oil content(s) of the beans. The water-soluble protein or nitrogen solubility index (NSI) was determined in the laboratory at 80° C for a 30-min extraction period on ground, whole soybeans at a water-to-meal ratio of 10:1. Results are shown in Table 2, column 4.

Good duplication for NSI values was obtained at 80° C, the temperature of maximum protein solubility, in contrast to poor duplication in earlier work at room temperature *(1)*.

Column 3, Table 2, shows the yield of tofu on a wet basis in kilograms and column 2 is the soluble protein (protein x NSI) plus oil content of the beans. Yields of tofu, column 3, for the Japanese beans are in the same order as the sum of soluble protein and oil content of the beans, column 2, but this generalization does not hold as well for U. S. beans. U. S. beans having the largest deviation from the general rule are Harosoy, Norchief, Adams, and Lincoln; there is no apparent reason for their deviations. Three runs were made on Harosoy, and the same low yield of tofu was obtained for each run.

Variations from the general rule may result partly from errors in processing and partly from other causes. Some contributing factors may be nonuniformity in the content of soluble sugars and other small molecular weight components of the beans and their nonuniform loss when filtering tofu in the mold and in leaching these soluble components when washing the final cake. Further studies on the character of beans and technique of processing will be necessary before a procedure is found that will give greater uniformity in yield.

Although there are rather large variations in tofu yield, the average for U. S. soybeans is 5.55 kg or 6% more than the average of 5.23 kg obtained from Japanese soybeans.

Quality of tofu. The quality of tofu is indicated by its volume or height in the mold, as well as moisture, hardness, coagulation, texture, and color (columns 9, 10, 11, and 12 of Table 1) and by its protein and oil content (columns 5, 6, and 7 of Table 2).

Large volume and high moisture are desirable properties for tofu, but there is no marked difference in these properties for the U. S. and Japanese beans. Although the average hardness is nearly the same for beans from the two sources, tofu from U. S. beans shows a wider variation in its hardness.

The most important differences between Japanese and U. S. soybeans, as viewed according to Japanese

TABLE 3

Percentage residue and its composition

Variety	Wet wt	Moisture content	Dry wt	Dry wt[1]	Protein	Oil	Protein lost[2]
	kg	%	g	%	%	%	%
Japanese soybeans							
Kumamoto	1.67	70	500	30.8			
Hakkaido[3]	2.01	77	460	27.0			
Nagano I	2.18	76	520	32.0	23.6	8.1	18.0
Nagano II[4]	1.76	75	440	26.2			
Aomori	1.96	76	470	29.0			
Miyagi[3]	2.35	79	500	31.0			
Average	2.03	76	475	29.2			
India	2.10	73	470	29.2			
U. S. soybeans							
Chippewa	1.70	77	390	23.4	22.5	11.4	12.3
Harosoy	1.96	75	490	29.3	26.7	13.7	18.2
Lincoln	1.98	76	480	28.7			
Clark	2.32	79	490	29.3			
Lee	1.90	76	460	27.5			
Adams	1.79	75	440	26.3	21.9	7.3	18.4
Dorman	2.27	78	500	30.0			
Jackson	1.79	76	430	25.7	21.3	12.7	13.1
Dortchsoy	1.79	70	540	32.3	20.9	15.7	17.7
O. Mandarin	2.01	78	440	26.3			
Blackhawk	2.46	80	490	29.3	22.2	6.1	16.7
Acme	1.79	74	470	27.1			
Comet	2.04	76	490	29.3			
Norchief	2.13	76	510	36.2			
Average	2.02	76	480	28.7			

[1] Calculated on dry weight adjusted for 10% and 7% moisture for Japanese and U. S. soybeans, respectively.
[2] Protein lost is the protein lost in the residue based on weight of protein in original soybens fter correction for moisture.
[3] Averge of two runs.
[4] Two liters of extra water used in extraction.

custom, are in the quality factors of coagulation, texture, and color. Quality of the tofu (Table 1) was judged by an experienced operator in the order of 1, 2, 3, with 3 representing the highest rating. Texture is judged by smoothness of the curd and appears to be controlled by the rate of coagulation.

Calcium chloride is frequently used to coagulate the curd. Occasionally magnesium chloride and even a concentrated fraction of sea salt have been used in China *(3)*. It was recognized earlier *(7)* that calcium sulfate is superior to the calcium or magnesium chlorides as it gives the most gelatinous type of precipitate and the smoothest texture. Most of the calcium sulfate is in suspension when added to the milk and the delay in going into solution appears to be a factor in producing a very gelatinous curd.

Tofu from Japanese varieties was mostly a greyish white color, whereas from U. S. beans the color was various shades of light yellow. The greyish white color is preferred in Japan and appears to be favored because of custom; several of the U. S. varieties gave a clear, pale yellow tofu which would appeal more than the grey-white color to people accustomed to cream and butter in their foods. However, the Lee and Jackson varieties were rated equal to Japanese beans for making tofu. Other U. S. varieties which were rated nearly equal to Lee and Jackson and which should be given further evaluation are Blackhawk, Clark, Hawkeye, Comet, Ottawa Mandarin, Acme, Dorman, and Dortchsoy. The Indian variety also made high-quality tofu.

As a food product, the protein and oil content are an important indication of basic food quality. The oil was determined by hexane extraction after drying the tofu in a vacuum oven for 2 hr at 105° C. The protein and oil of the tofu appear to be roughly related to the soluble protein plus the oil of the particular soybeans used. However, the results lack uniformity probably because of the same reasons mentioned under the discussion on yields.

Tofu from Japanese beans so far investigated averages about 3.5% higher in protein than U. S. beans, but the oil is lower by about the same amount. Thus the difference for the sum of protein and oil is less than 1%. However, this conclusion should not be generalized for all soybeans as work on additional varieties would be expected to give some modification in results.

Residue. Information on the residue from the filtration of the milk is shown in Table 3. These data show that about 29% of the original beans on a dry-weight basis are recovered in the residue. The number of Japanese varieties used is too limited for a final conclusion, but results indicate that the unextracted protein and oil in the residue amounts to about the same for either Japanese or U. S. beans.

CONCLUSIONS

Tofu made in pilot-plant investigations from different varieties of U. S. and Japanese soybeans showed observable differences in color and texture. Because uncomposited samples of soybeans were used, observed differences may have been caused by climate and soil at the location of their growth. Lee and Jackson varieties appeared to make tofu equal to that from Japanese soybeans. Tofu from several other U. S. varieties were only slightly different in color and texture. Yield of tofu varies with variety (location), but the general average yield from U. S. soybeans is about the same as from Japanese beans. Original protein and oil content of the beans is a factor in yield and in the final protein and oil content of the tofu.

LITERATURE CITED

1. Belter, P. A., and Smith, Allan K. Protein denaturation in soybean meal processing. *J. Am. Oil Chemists' Soc.*, 29, 170 (1952).
2. Carter, J. L., Bernard, Chamberlain, Lawrence, Ruth, and Younger, Caroline. Results of cooperative uniform tests, Parts I and II. U. S. Regional Soybean Laboratory, Crops Research Division, U. S. Department of Agriculture, Urbana, Illinois (1959).
3. Smith, Allan K. Oriental methods of using soybeans. U. S. Department of Agriculture, AIC-234, June 1949.
4. Smith, Allan K. Use of U. S. soybeans in Japan. U. S. Department of Agriculture, ARS-71-12, April 1958.
5. Smith, Allan K. Research on increasing the use of U. S. soybeans in Japan. *Soybean Digest*, 19 (11) 62 (1959).
6. Standard tables of food composition, compiled by Resources Council, Prime Ministers Office, Japan (1954).
7. Watanabe, T., et al. Studies on Tofu, Report of the Food Research Institute, No. 14. In Press.
8. Watanabe, T., and Shibasaki, K. Japanese scientists look at U. S. soybeans. *Soybean Digest*, 19 (11) 66 (1959).

The Picric Acid Turbidity Test: A Possible Practical Freshness Test for Iced Shrimp

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An approach of possible usefulness in developing a satisfactory freshness test for iced shrimp was discovered by chance during the course of a well-known preparatory procedure for the analyses of free amino acids of spoiled and unspoiled shrimp *(4)*. The procedure *(5)* consisted of precipitating protein with 75% ethanol, heating, and adding saturated aqueous picric acid solution to permit the determination of free amino acids in the clear supernatants obtained after centrifugation. It was surprising to find that clear supernatants were derived from unspoiled shrimp; quite turbid supernatants, from spoiled shrimp. This observation stimulated speculation as to the value of the procedure, or a possible modification of it, as a freshness test for iced shrimp.

No truly satisfactory single freshness test for iced shrimp exists today *(2, 3)*. Indications of spoilage based on changes in content of trimethylamine nitrogen, volatile acids, bacterial count, sulfhydryl groups (iodine titration), and ammonia (Nessler's reagent) become evident only after spoilage is apparent organoleptically. Increments of change in hydrogen-ion concentration, amino nitrogen, hydration of water-insoluble protein, and sulfhydryl groups (ferricyanide titration) are small, and results are variable. Tests for glycogen-sugar, lactic acid, and acid soluble orthophosphate indicate changes during the very early stages of spoilage, but these constituents disappear from shrimp tissue before loss of prime quality is detected organoleptically. Most of these tests are lengthy and somewhat difficult to conduct—which limits their commercial application. In short, existing tests, though fundamentally interesting, do not meet the practical needs of the shrimp industry.

In the preparatory procedure described above for free amino acid analyses, it was found that a clear-cut difference in response occurs that may be of use in distinguishing spoiled and unspoiled shrimp. But in deciding whether or not the procedure has any value as a satisfactory and practical freshness test for iced shrimp, this is not the only consideration. The first problem is to determine if the procedure can be simplified to the point where it becomes a quick and inexpensive practicable operation. A number of requirements must be met. Thus, studies to establish optimum conditions of testing would be required, and it would also be necessary to find out whether sufficient amplification of quantitative differences between the fresh and spoiled shrimp can be obtained with enough ease so that personnel with limited technical background could apply it. Moreover, the procedure, an objective test, would have to be related to organoleptic evaluations so that the incidence of off-flavor and odor could be recorded. Finally, the procedure would have to be applicable in a commercial situation.

The development and testing of such a procedure, termed the Picric Acid Turbidity Test, is described in the present report. The test would appear to meet the requirements specified above.

DEVELOPMENTAL STUDIES

For the developmental studies, a 30-lb lot of white shrimp *(Penaeus setiferus)*, ranging in size from 32 to 40 shrimp per lb, was used. These shrimp were from a single catch made off the Georgia coast near Brunswick. The lot was frozen immediately upon arrival at the dock, which was several hours after catching, and then sent by air express to this laboratory. Testing was begun immediately. At 2–3 day intervals, 2-lb sub-lots of shrimp were removed from frozen storage, layered in ice, and held in a refrigerator at 38° F for 11–12 days. Thus, testing could be conducted simultaneously on frozen-control shrimp and on shrimp permitted to spoil in ice for 11–12 days. Initial organoleptic evaluation of the lot showed that iced storage of this duration resulted in a borderline quality product. That is, the shrimp were less than fair quality but not inedible.

Simplification of testing. Simplification of the test to assure quick and inexpensive operation was achieved by stepwise modifications of the manipulations required to prepare shrimp tissues for free amino acid analyses. Each modification was considered satisfactory if turbid filtrates were obtained with the 11–12 day iced-stored shrimp and clear filtrates with the frozen or control shrimp.

The time required to conduct the procedure was reduced from several hours to about 15 minutes by (a) utilizing a mechanical blender to macerate the sample, and to contain and mix all reagents with the sample; (b) eliminating the use of heat; and (c) filtering the slurry through paper designed for use with large particle precipitates.

Optimum conditions of testing. The modifications specified above were used to study alterations in testing conditions that might amplify the observed difference between spoiled and control shrimp. Alterations of each testing condition were studied individually, each optimum condition[a] being employed in a study of subsequent alterations. No attempt was made to study alterations in combinations of testing conditions.

A Klett-Summerson Photoelectric Colorimeter was employed to quantify differences. A transmission wavelength of 540 mmc (green filter) was used to filter out the color of the picric acid, making it possible to measure only the turbidity. A sample size of 25 g was chosen for testing. The volumes of ethanol and picric acid used permitted easy blending and manipulation but also provided for a sufficient amount of material for analyses. The filtrate was collected directly into Klett tubes.

RESULTS AND DISCUSSION

The effect of varying the concentration of ethanol was first studied. The results (Figure 1) indicated that the greatest difference, and thus the optimum condition, resulted when 70% ethanol was used.

[a] Alterations judged to be optimum were those that yielded maximum turbidity with the iced-stored shrimp while yielding little or no turbidity with the control shrimp.

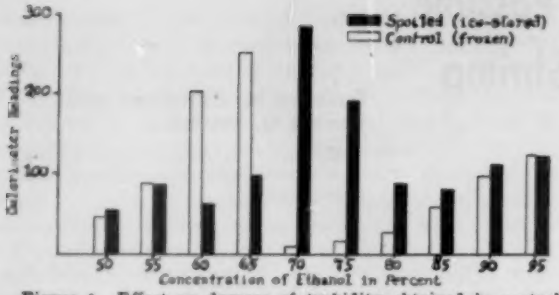

Figure 1. Effect on degrees of turbidity obtained in control and ice-spoiled shrimp of varying the concentration of ethanol in developing the PAT test.

When alcohol without the picric acid was used, the result was considerable turbidity in filtrates of the control shrimp and somewhat less turbidity in filtrates of the spoiled shrimp. When alcohol only was employed, turbidity values tended to gradually decrease as shrimp were tested during iced storage. Clear filtrates were never obtained.

The effect of varying the concentration of picric acid in solution was examined. Results (Figure 2) showed that only with saturated picric acid did filtrates of the control shrimp remain clear. Filtering time was too slow and turbidities appeared in both control and spoiled shrimp when concentrated picric acid was used without prior use of alcohol.

With regard to the effect of using filter papers of varying Whatman numbers, the results (Figure 3) indicated that almost any filter paper except numbers 52 and 54 could be used. With these, there was some turbidity when the control shrimp were tested. As to the remaining filter papers, filtering time was much too slow to be of any practical value except with numbers 4, 31, and 41 (designed for use with gelatinous or large particle precipitates). The greatest difference between the control and spoiled shrimp was obtained by use of Number 41 filter paper.

The effect of altering the pH of solutions before and after filtering was studied. No filtrate could be collected (due to the formation of gelationous materials) when acetic acid, hydrochloric acid, or sodium hydroxide were added to the slurry before filtering. Clear filtrates from the control shrimp became turbid when acetic acid or hydrochloric acid was added to the filtrates themselves. When sodium hydroxide was added to these turbid acidified filtrates of the control shrimp, clearness of filtrates was again obtained. Turbid filtrates, resulting normally from spoiled shrimp, became clear when sodium hydroxide was added to the filtrate. Turbidity returned when the pH of the solution was adjusted to the acid side with hydrochloric acid.

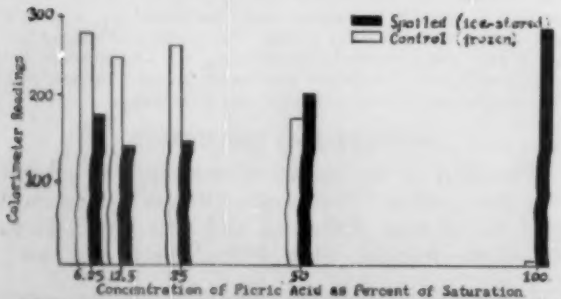

Figure 2. Effect on degrees of turbidity obtained in control and ice-spoiled shrimp of varying the concentrations of picric acid in developing the PAT test.

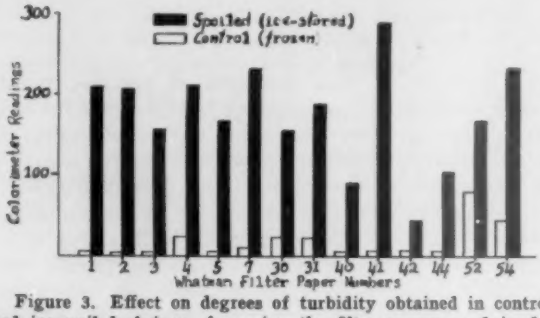

Figure 3. Effect on degrees of turbidity obtained in control and ice-spoiled shrimp of varying the filter papers used in developing the PAT test.

The simplified procedure (termed the Picric Acid Turbidity Test, or PAT test), which presumably represented optimum conditions for subsequent testing, is performed as follows:

1. A sample of shrimp is peeled, deveined, and weighed on a trip balance.
2. The shrimp are macerated for about 30 sec in a mechanical blender with a volume of 70% ethanol equal in weight to four times that of the sample.
3. Saturated aqueous picric acid solution is added to the slurry in the blender in an amount equal to the weight of the shrimp, and the slurry is reblended for about 20 sec.
4. The slurry is filtered immediately through Whatman number 41 filter paper, and about 10 ml of the filtrate is collected in a 15-ml test tube.
5. The degree of turbidity of the filtrate is measured with a suitable instrument, correcting for a blank prepared with the reagents above but substituting a volume (ml) of water equal to the weight (g) of the sample of shrimp to be tested.

ORGANOLEPTIC AND PAT TEST EVALUATIONS OF ICED SHRIMP DURING STORAGE

The PAT test, used as described above, was used for storage studies to determine whether or not the incidence of turbidity is related to organoleptic evaluations of quality change. Sample size and variability expected from testing were also considered in these studies. For the organoleptic evaluations, a panel of 5 members graded the various samples of shrimp (peeled, deveined, and boiled for 5 min) but only on the basis of flavor and odor; texture and appearance may be affected by factors other than spoilage. The categories of quality used by the panel were:

High: Delicate flavor; no detection of off-flavors or odors.

Good: "Shrimp flavor"; no detection of off-flavors or odors.

Fair: "Strong shrimp flavor"; detection of slight off-flavors and/or odors.

Borderline: Waning "shrimp flavor" and/or noticeable off-flavors and/or odors, but still edible.

Inedible: Strong and offensive off-flavors and/or odors.

After the shrimp were graded by the panel, numerical values of 5, 4, 3, 2, and 1 were assigned to the above categories in the order of decreasing quality.

The freshness of 4 lots of iced shrimp was evaluated during storage. The findings from lot 1 (initial study) are reported in detail. Those from the remaining 3 lots (confirmatory study) are reported only briefly since these findings were similar to those of the first study.

Initial study. One net load of 105 lb (lot 1) of Texas brown shrimp *(Penaeus aztecus)* caught off the Texas coast near Brownsville and ranging in size from 28 to 32 shrimp per lb was frozen immediately upon being landed and then sent by air express to this laboratory.

Of the 105 lb, 25 lb were retained in frozen storage at −20° C for use as control samples. The remaining 80 lb were defrosted overnight at 2° C and layered in crushed ice the following morning. The shrimp were re-iced every 2 days during the test period.

The PAT test was conducted daily on (a) two 50-g samples of frozen-control shrimp, (b) two 25-g samples of iced shrimp, (approx 3 shrimp each), (c) two 50-g samples of iced shrimp, (approx 6 shrimp each), (d) two 100-g samples of iced shrimp, (approx 12 shrimp each), (e) 3 individual frozen-control shrimp, and (f) 3 individual iced shrimp. The degree of turbidity was measured in two filtrates from each of the samples and individual shrimp tested.

An organoleptic test was conducted on the two samples, one from the frozen-control and the other from the iced shrimp, on the following sequence of days—1, 3, 5, 8, 10, 12, 15, 17, and 19 (Mondays, Wednesdays, and Fridays). The study was ended on the 19th day, when all of the iced shrimp were inedible. Data are presented in Table 1.

The filtrates were clear in appearance when photoelectric colorimeter values were about 30 or less, slightly turbid when the values were between 30 and 100, and very turbid when the values were over 100. In general, shrimp with filtrates reading about 30 or less received organoleptic ratings of *high* or *good;* those with readings between 30 and 100 received ratings of *fair;* and those with readings over 100 received ratings of *borderline* or *inedible.*

The shrimp stored in ice were of high quality from the 1st through the 5th day, and the filtrates were always clear. The shrimp were of fair quality from the 6th through the 10th day, the filtrates, generally, being between 30 and 100. Two members of the taste panel indicated that they could detect minute off-flavors and odors in the iced shrimp on the 8th day, *i.e., 2 days after the chemical test indicated a change.* The shrimp were of borderline to inedible quality from the 11th through the 19th day, and the filtrates, generally, were over 100. At the end of this time all of the iced shrimp were inedible. The frozen shrimp were of *high* to *good* quality throughout the entire study, and the filtrates were clear without exception.

After the period of good or high quality had passed, the readings for the individual shrimp stored in ice showed considerable difference on a given day. This may be due to variation in the initial quality of the shrimp or to individuality in spoilage. These differences between individual shrimp may explain, at least in part, the greater variation from sample to sample in the data for the 25-g samples than in the data for the 50- or 100-g samples. No explanation is apparent, however, for some of the low turbidity values of the 50- and 100-g samples between the 6th and 10th days of iced storage—unless, of course, these low values reflect an unintentional chance selection of better quality shrimp. Nevertheless, by utilizing increased numbers of individual shrimp, or 25-g samples, rather than smaller numbers of larger sized samples, information should be more readily collected and the variability in quality within the lot of shrimp more precisely determined. A mean value for a series of small samples would indicate the over-all quality of the lot. Slightly more information as to the within-lot variability would result from tests of individual shrimp as opposed to tests from 25-g samples of shrimp. However, the added effort involved in adjusting the quantity of the reagents to the weight of each individual shrimp would not be feasible in practical applications of the test. A great deal of the variability would be eliminated, no doubt, if large quantities of shrimp were homogenized or cut up and mixed, and if testing were conducted with aliquots of samples thus handled. Again, however, practical application must be considered. For these reasons, the 25-g sample size was used in further testing. It should be noted, however, that regardless of any variations, the data—whether for individual shrimp or for larger samples—correlated with the results of organoleptic tests.

Confirmatory study. Lots 2, 3, and 4 of the original 4 lots of shrimp were used in the confirmatory study. Lot 2 (25 lb of Texas brown shrimp, *Penaeus aztecus*) was caught in the Gulf of Mexico and iced immediately after being landed on the vessel. Since the vessel docked on the same day, the lot probably represented shrimp from not more than a few net loads. As soon as the vessel docked, the shrimp were re-iced and sent by air express to the College Park Laboratory. This lot was not frozen prior to testing which took place on the following day. Lots 3 and 4 (25 lb each of Campeche pink shrimp, *Penaeus duroram*) were obtained from freezer vessels. It is not known how many net loads were represented. Both of these lots of shrimp, however, were bisulfite dipped [b] and were frozen within a few hours of being caught on the Campeche fishing grounds, Gulf of Mexico. These lots were sent to the laboratory in the frozen state.

Lots 2, 3, and 4 were treated in the same manner during testing—that is, half of each lot was placed in *frozen storage at −20° C and the remaining half iced* and placed in a refrigerator at 2° C. The ice was replaced every 2 days.

The PAT test was conducted in duplicate daily on

[b] An aqueous solution of 1¼% technical grade sodium bisulfite used commercially to retard the formation of black spot.

two 25-g samples of the iced and frozen shrimp; the organoleptic test every Monday, Wednesday, and Friday until the iced shrimp of each lot was considered inedible.

All filtrates were clear when the frozen-control samples of shrimp were tested for lot 2 (brown shrimp) and for lots 3 and 4 (pink shrimp). All filtrates were clear also when the iced shrimp were tested until the 7th, 10th, and 12th day of testing for lots 2, 3, and 4, respectively. The filtrates were turbid on each of these days and every day thereafter during the remainder of each test period. In every case, changes in the shrimp as indicated by the incidence of turbidity were directly related to an organoleptic indication of loss of good quality.

IN-PLANT STUDY

The PAT test appears satisfactory for use with lots of shrimp of (a) known and ideal history, (b) initial high quality, and (c) theoretically limited variability. The controlled conditions possible in a laboratory were a factor in limiting variability. The final criterion for a practical test would be its performance under "normal" commercial conditions. Such conditions should include: (a) variability of individual shrimp, which in commercial practice may be great owing to different conditions of handling and holding the shrimp both on the boats and in the processing plants, (b) evaluations of shrimp by plant personnel, which may differ in some degree from the evaluations of quality by a laboratory trained organoleptic panel, and (c) processing, which may affect the test adversely. These considerations led to a field study, conducted in a shrimp processing plant, to evaluate the commercial application of the PAT test.

The in-plant study. Samples of iced shrimp as received at the plant and at various stages of processing were submitted to the PAT test. Turbidities from these samples were evaluated by means of comparison tubes, prepared previously to read 30 to 100 on the photoelectric colorimeter. Since these comparison tubes read 30 and 100 after the study was completed, a colorimeter was not required. Evaluations of the general quality of the lots of shrimp were made by experienced plant personnel.

Descriptions of the various lots of shrimp tested and the test results are shown in Table 2. Lots 1–5 were received for processing, whereas lots A and B (sublots of lots 1 and 5, respectively) were purposely permitted to spoil. Six samples were tested in duplicate at each of 5 progressive stages of processing for each of the 7 lots of shrimp. Lots 1 through 5 were processed as usual for marketing; experimental lots A and B were specially processed as "normally" as could be simulated. In every case, any turbidity present in the lots of shrimp as received diminished somewhat during each stage of processing until all filtrates from all samples were clear in the final

TABLE 1

Quality changes of iced shrimp during storage as indicated by the picric acid turbidity test and an organoleptic test

Testing period in days	Individual and mean[1] values[2] indicating the degree of turbidity[3] of filtrates														Mean organoleptic values[4]	
	Weighed quantities of shrimp								Individual shrimp							
	50-g frozen-controls		25-g samples iced		50-g samples iced		100-g samples iced		Frozen			Iced				
	Instrument readings															
	A	B	A	B	A	B	A	B	A	B	C	A	B	C	Frozen	Iced
1	22	21	22	23	22	21	20	20	22	24	25	22	24	25	5.0	5.0
2	27	25	30	30	16	17	12	9	18	30	33	32	30	72		
3	18	20	18	19	18	19	18	14	29	24	13	14	14	11	5.0	4.8
4	19	19	13	18	14	18	11	9	16	28	24	34	73	37		
5	0	1	10	11	12	13	9	7	5	9	9	12	13	13	4.8	4.4
			19.6[5] ± 7.7[6]		17.0 ± 3.3		12.8 ± 5.0					28.4 ± 17.0				
6	13	10	100	141	15	31	16	91	16	17	24	154	20	88		
7	15	8	73	47	27	62	48	72	9	28	10	129	35	44		
8	11	11	28	69	47	56	70	49	14	10	29	123	19	105	5.0	3.6
9	18	18	65	150	39	18	29	39	20	21	22	155	131	118		
10	20	20	43	42	19	27	26	27	19	24	22	23	23	21	5.0	3.2
			75.8 ± 35.7		34.1 ± 13.1		46.7 ± 15.5					79.2 ± 40.3				
11	16	14	174	144	146	101	125	30	36	18	46	178	185	181		
12	15	11	187	238	182	185	141	115	18	21	21	179	116	195	4.8	2.4
13	9	8	126	119	151	186	122	137	13	26	11	73	122	124		
14	10	12	122	135	154	165	130	115	19	14	73	160	146	92		
15	18	13	125	139	110	99	101	113	40	50	47	88	99	149	5.0	1.4
16	13	23	126	116	160	122	127	128	14	26	14	166	116	94		
17	10	6	180	136	155	140	129	128	12	52	18	117	80	102	4.6	1.2
18	20	20	161	159	128	138	154	133	131	17	18	104	108	103		
19	12	15	124	110	157	111	104	97	20	11	9	72	160	87	4.6	1.0
			145.6 ± 30.5		143.9 ± 24.0		118.3 ± 20.0					127.1 ± 32.7				
	14.5 ± 6.1								24.4 ± 19.0							

[1] Duplicate analyses.

[2] Values are instrument readings obtained using the Klett-Summerson Photoelectric Colorimeter with green filter.

[3] Readings of 30 or less appear clear visually; readings of 30–100 appear slightly turbid or murky; readings of 100 or more appear quite turbid. For ease of interpretation, data have been arbitrarily subgrouped within these limits.

[4] Every Monday, Wednesday, and Friday an organoleptic panel of 5 members graded the shrimp on the basis of flavor and odor into the following categories of quality: high, good, fair, borderline, and inedible. The numerical values of 5, 4, 3, 2, and 1 were assigned to these categories of quality, and it was decided, arbitrarily, that a mean value of 5.0 indicates high quality and mean values ranging from 4.0–4.9 indicate good quality; from 3.0–3.9 indicate fair quality; from 2.0–2.9 indicate borderline quality; and from 1.0–1.9 indicate inedible quality.

[5] Grand mean of daily means.

[6] Standard deviation of the mean.

product. This prevailed whether the product was breaded shrimp or cocktail shrimp, that is, deveined and individually frozen. A positive test was never permanently "lost" since very turbid filtrates resulted when the remainder of the breaded shrimp of lots A and B were held at 8° C for several days. However, the standard debreading operation of removing the breading with rapidly moving water for 10 min *(1)* led to a loss of turbidity again.

It is noteworthy that the PAT test evaluation of the quality of lots of shrimp is very closely related to plant personnel evaluation of the quality of the shrimp (Table 2). In this connection, it should be recalled that evaluations based on the PAT test (degrees of turbidity) were founded initially on quality evaluations of a laboratory-trained organoleptic panel.

Two additional observations made in connection with this study should be of interest to any person attempting application of the test. The test appears to be thermally dependent—at above normal room temperature (95° F and over) turbidity develops even in samples of shrimp of good quality. Also, when shrimp are permitted to spoil at high temperatures without ice and become extremely dehydrated, the results are unreliable.

TABLE 2

Comparison of PAT test and plant personnel evaluations of the quality of lots of shrimp

Lot	Description	Plant personnel evaluation	PAT test evaluation
1	Approx 6,000 lb; predominantly brown shrimp, 50–60 count; had been obtained from Panama approx 6 mo previously and held in frozen storage until processing.	Fair quality, somewhat dehydrated	x[1] x xxx x x x
2	Approx 1,000 lb; local white shrimp, 28–32 count; caught on one-day run, docked next door to plant, held in cooler overnight, processed next morning.	Excellent quality	x x x x x xx
3	Approx 4,300 lb; local mixed white and brown shrimp, 28–30 count; caught on one-day run, docked 30 mi north of plant, trucked to plant on ice, held in cooler overnight, processed next morning.	Excellent quality	x x x x x x
4	Approx 3,000 lb; Campeche pink shrimp, 26–30 count; caught on Campeche shrimping grounds in Gulf of Mexico, transferred from trawler to ice-relay boat that required approx 72 hr to reach Tampa from shrimping grounds, transferred to ice-truck that required 1–2 days to deliver shrimp from Tampa to plant; shrimp processed immediately.	Good	xx x x xxx x x
5	Approx 5,500 lb; Campeche pink shrimp 26–30 count; similar history as Lot 4.	Good and fair	x xx xx xxx xx x
A	Approx 20 lb of Lot 1 above were stored in ice in a cooler and purposely permitted to spoil; then they were processed "normally."	Unfit for human consumption	xx xxx xxx xx xxx xxx
B	Approx 20 lb of Lot 5 above were stored in ice in a cooler and purposely permitted to spoil; then they were processed "normally".	Unfit for human consumption	xxx xxx xx xx xxx xxx

[1] x—clear test filtrates. xx—slightly turbid filtrates. xxx—very turbid filtrates. Each of these values represents a mean of duplicate analyses.

DISCUSSION

The industry's expressed and urgent need for an objective freshness test for iced shrimp superseded some initial desire to inquire into the nature of the turbid supernatant noted when spoiled shrimp were being prepared for free amino acid analyses. This might have been an isolated instance. It seemed reasonable to suppose, too, that more direct pathways were available to study spoilage in shrimp.

Results presented herein, however, suggest a relation betwen the incidence of turbidity as shown by the PAT test and a loss of quality of iced shrimp as measured organoleptically. It is recognized that during the entire period of iced-storage testing, turbidity values did not increase continuously as the quality of the shrimp (subjectively judged) became progressively poorer. For instance, in the initial study, fairly constant turbidity values on individual shrimp (when turbidity was obtained at all) were recorded.

It might be considered that this relationship between the incidence of turbidity as shown by the PAT test and the loss of quality of the shrimp as evaluated organoleptically is incidental. Although this does not seem likely, the substance causing turbidity may not be the prime reason for the increasingly poorer quality (organoleptically judged) as spoilage progresses. It is probable that an increasing number of compounds contribute to the sum total of organoleptic sensations. This conjecture seems even more plausible when the "all or none" reaction is considered. Quite possibly, during iced storage, normal shrimp tissue is continuously being altered and a "substance" is formed that is primarily and preferentially being measured by the PAT test. This postulated substance might then be concomitantly and continuously eliminated from the shrimp tissue by the leach water from the melting ice and/or be further altered and not measured. Naturally, enough substance would have to be present in the tissue at any instant to permit the positive testing.

There is a likelihood therefore that the objective and subjective evaluations are measuring different substances—which probably accounts for the sensitivity of the PAT test. Of course, loss of good quality might be the result of measurement of the "substance" by both the objective and subjective tests.

During the development of the PAT test optimal response was obtained under rather limited experimental conditions. The 70% alcohol and saturated picric acid solution are functioning apparently as a protein dehydrant and as an alkoloidal reagent, respectively. Both are necessary to prevent formation of turbidity when the control, or good quality, shrimp are tested.

Perhaps during spoilage basic changes in size and

surface properties occur in the normal tissue protein of the shrimp and formation of colloidal fragments is permitted—with stability to the alcohol and picric acid different from that of unaltered protein. Further, it is not unlikely that the turbidity observed is primarily insoluble picrates of the altered protein particles. Thus, the picric acid would be functioning in a dual role in the PAT test. And it must be admitted that the limited data available do not rule out other possibilities.

The visible observation, for instance, might be only an indication of denaturation—a less drastic change in protein structure. It is reasonable, too, to propose that picrates of different amines and other materials might comprise a part of the turbidity observed since various intermediate and end products of protein decomposition are known to occur in iced stored shrimp *(2)*. The nature of resultant substances measured with the PAT test is currently being considered at this laboratory. Thus far, explanation of the mechanisms involved is somewhat complicated by the need to test the possibility of non-homogenity of test results throughout the entire period of storage. Causal factors underlying the mechanisms are also being considered. It is not clear whether they represent autolytic activity of the tissue enzymes and/or are the result of physical agents such as bacteria. At present, the mechanisms involved seem to be primarily autolytic in nature. Further study is needed to explore this supposition.

The applicability of the PAT test as a practical freshness test of iced shrimp requires the careful examination of several seemingly different results obtained during the conduct of the study. Further analysis of the possible commercial usefulness of the PAT test will be needed. For instance, it is to be noted that initial incidence of turbidity was observed on different days for each of the various lots of shrimp tested. In each case, however, the location and the method of handling the catch might very reasonably account for the difference in the length of time the iced shrimp would be expected to remain unspoiled. It is general knowledge among fishery technologists, processors, etc., that shrimp obtained from the Campeche grounds retain high quality longer than shrimp taken off the Gulf coast. Also, there is no apparent explanation for the unusually high turbidity values recorded during the developmental studies with the white shrimp. Turbidity values obtained during the subsequent testing of other lots of shrimp were never so high as for white shrimp. Perhaps these higher values indicate some native difference between the composition of Atlantic and Gulf shrimp.

During the in-plant study of the usefulness of the PAT test under normal conditions, it was encouraging to note that plant personnel evaluations of the general quality of lots of shrimp correlated with evaluations utilizing the PAT test. The fact that turbidities originally observed diminished somewhat during each processing stage suggests that the possible usefulness of the PAT test lies in the evaluation of the quality of incoming lots of iced shrimp—before processing.

For the commercial application of the PAT test, the question of adequacy of sampling must be considered. Results of the in-plant study indicated that the number of samples to be tested (i.e., adequacy of sample) would depend primarily on the within-lot variability. This finding will require further study. However, personnel of this plant were of the opinion that tolerance limits could be established. Such limits could be set in terms of the number of "turbid" samples permitted in incoming lots of shrimp of specified total weight.

The final evaluation of the PAT test as a commercially practical freshness test of incoming lots of iced shrimp must await the results of more extensive testing. It is to be hoped that other fishery technologists, noting the data presented here, will be motivated to evaluate the PAT test. In the final evaluation of the PAT test, basic knowledge of the mechanisms that lead to the clean-cut difference in supernatants of control and spoiled shrimp would be of great value. Lacking this, however, empirical knowledge should not be ignored, since it may open the way to the development of a freshness test for iced shrimp that will meet the requirements of the industry.

CONCLUSIONS

A freshness test for iced shrimp has been developed and tested under laboratory and commercial conditions. Data indicate:

1. The test is simple and easy to perform, takes about 15 minutes to conduct, and requires only a small amount of inexpensive apparatus and chemical reagents.
2. The test permits a clear-cut indication of loss of quality in iced shrimp and test results correlate with organoleptic evaluations.
3. The most practical commercial application appears to be in the evaluation of lots of iced shrimp.
4. Only extensive application will determine the actual value of this test as a freshness test for iced shrimp in a practical commercial situation.

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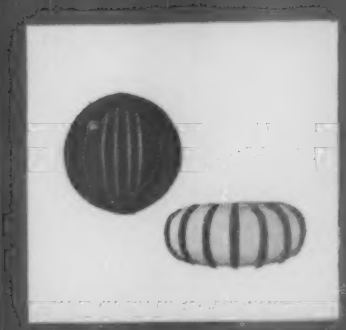
LITERATURE CITED

1. Anonymous. *Federal Register*, 23, 130 (1958).
2. Bailey, M. E., Fieger, E. A., and Novak, A. F. Objective tests applicable to quality studies of ice stored shrimp. *Food Research*, 21, 611 (1956).
3. Fieger, E. A., and Friloux, J. J. Comparison of objective tests for quality of fresh and frozen Gulf shrimp. *Proc., Gulf and Caribbean Fisheries Inst.*, 6th Annual Session, 106 (1953).
4. Kurtzman, C. H., Snyder, D. G., and Nilson, H. W. Cystine and total sulfhydryl content of unspoiled and spoiled shrimp. *Food Research*, 25, 237 (1960).
5. Roberts, E., Lowe, I. P., Chanin, M., and Jelinek, B. Free and easily extractable amino acids of the heart muscle of various species. *J. Exp. Zool.*, 135, 239 (1957).



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A Technique Utilizing 2, 3, 5 Triphenyltetrazolium Chloride for Recognition of Bacterial Colonies in the Presence of Large Numbers of Food Particles[a, b]

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IN ORDER TO CIRCUMVENT the difficulty involved in differentiating between food particles and bacterial colonies, techniques such as the surface swab and serial dilution (most probable number, decimal dilution) have been used in the past. Angelloti *et al (1)* evaluated the cotton swab technique with reference to the recovery of a known contamination and the precision between successive recoveries of this known contamination. They concluded that the cotton swab technique was low in recovery and low in precision. Ziegler and Halvorson *(11)* found that the serial dilution method was less accurate and less precise than the standard plate count even when 10 tubes were used at each dilution. The technique herein reported appears to offer an improvement in precision and accuracy over the cotton swab, the serial dilution, and the standard plate count as described in *Recommended Methods for the Microbiological Examination of Foods (7)*, when low bacterial contamination is present in a food product.

Goetz and Tsuneishi *(5)* reported that 2,3,5 triphenyltetrazolium chloride, as a component of bacterial media, facilitated the detection and counting of microorganisms. However, Fifield and Hoff *(4)*, and Weinberg *(10)*, reported that 2,3,5 triphenyltetrazolium chloride was a growth inhibitor of many organisms in concentrations as low as .04% and .05%. The ability of bacteria to reduce the 2,3,5 triphenyltetrazolium chloride to the insoluble and red-colored formazan form *(9)* could, therefore, not be utilized to obtain total counts of mixed cultures if the indicator solution were incorporated into the growth medium.

Since it was found with several food products, both after processing and in the raw sterile state, that no reduction of the indicator solution occurred when it was added to the product, and since 2,3,5 triphenyltetrazolium chloride solution was capable of diffusing through a thin layer of agar within a reasonable period of time, further investigation looking toward the development of a technique utilizing this chemical agent to aid in the recognition of bacterial colonies was considered worthwhile.

After plate cultures of food products have been prepared in accordance with standard methods and incubation has been completed, the ease of colony recognition is a function of the sample dilution. To the naked eye, the medium in which bacterial colonies have grown may vary from total opacity to complete transparency. In cultures prepared from low dilutions of food products, bacterial colonies may be masked by food particles or food particles may appear to be bacterial colonies. In order to eliminate these problems the Tetrazolium Flooding Technique was developed.

THE TETRAZOLIUM FLOODING TECHNIQUE

Each culture of plated food material, after proper incubation, was removed from the incubator and was flooded with 2 ml of a 0.1% aqueous solution of 2,3,5 triphenyltetrazolium chloride. The flooded plate was gently rocked back and forth and from side to side several times so that the entire area was covered by the solution. The excess solution was poured off, the Petri dish cover replaced, the plate inverted and allowed to remain at room temperature for 3 to 5 hr. The metabolizing bacterial colonies normally reduced the indicator solution within the first hour. The additional time used allowed the more slowly metabolizing colonies to reduce the tetrazolium and also resulted in color intensification within all of the colonies.

In counting the colonies an illuminating instrument such as the Quebec Colony Counter was found satisfactory except in the case of extremely opaque media. When the latter situation existed, a more powerful light source was required to penetrate the growth medium. Exposure of the Petri dish culture to an uncovered 100 w lamp proved satisfactory.

EXPERIMENTAL

Chicken meat of very low bacterial content. This experiment was performed in the course of testing aseptically removed chicken breast muscle for sterility. It illustrated the usefulness of the above described technique in plate cultures of extreme opacity.

Pieces of chicken meat totaling 91.9 g were placed in a sterile blender together with 99 ml of chilled sterile water. After grinding for 4 min, 3 g of the slurry was weighed into each of 8 Petri dishes. Since each gram of slurry contained 0.48 g of chicken meat, each Petri dish contained 1.44 g of chicken meat.

Approximately 15 ml of molten Tryptone Glucose Extract agar (Difco Laboratories, Inc., Detroit, Michigan) was added to each dish. The slurries were dispersed in the agar by stirring with a sterile glass rod followed by gentle rotation and agitation of the dishes. After the agar solidified, the dishes were inverted and placed in a low humidity incubator at 37° C for 36 hr. The dishes were then removed from the incubator and subjected to the Tetrazolium Flooding Technique described above. The colonies were counted by exposure of the dishes to a naked 100 w lamp and noting the red spots within and on the surface of the medium.

Chicken meat inoculated with a pure culture of Escherichia coli ATCC 9637. In higher dilutions in which pieces of

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chicken were numerous, but ordinary plate counting techniques could be attempted, the tetrazolium technique was tested to determine whether the method could be used to increase the accuracy and precision of the plate count.

Discs of sterile chicken meat of approximately 1 sq in surface area and ¼ in thickness were cut and inoculated with approximately 10,000 cells of an 18-hr culture of *E. coli*. The discs were incubated at 37° C. After various periods of incubation, discs were selected, removed from the incubator, and placed in a sterile blender cup together with 99 ml of chilled sterile water. After grinding for a period of 4 min a series of dilutions were plated using Tryptone Glucose Extract agar (Difco) as the nutrient medium. When the medium solidified the dishes were inverted and incubated at 37° C.

After 24 to 36 hr the plates were removed from the incubator, the discernible colonies were counted using a Quebec Colony Counter, and the results were recorded. The plates were then subjected to the Tetrazolium Flooding Technique, after which they were recounted, again using a Quebec Colony Counter, and the new results were recorded. Comparison of the two sets of data was then made.

Flounder skin containing natural microbial flora. The object of this group of experiments was to determine the degree of error which could be introduced into an experiment through the failure of some colonies in a mixed culture to reduce the indicator solution.

Fresh-caught flounders were stored at refrigerator temperatures. After selected storage periods a 2 sq in piece of skin was aseptically removed, placed in a sterile blender cup together with 99 ml of sterile water, and ground for 3 to 4 min. The dilutions plated were 10^{-3}, 10^{-4}, and 10^{-5}. Fish extract Tryptone Glucose Extract agar *(6)* was used as the plating medium. Incubation was carried out at 20° C for 5 days. The plates were then removed from the incubator, the colonies counted using a Quebec Colony Counter, and each colony was encircled with green crayon on the underside of the dish. The plates were then treated with the Tetrazolium Flooding Technique, after which each green circle was inspected for the reduction of the indicator. The plates were also examined for the presence of reduction in areas where no obvious colony had been observed earlier. The results were recorded and data comparison was accomplished.

Pre-cooked turkey meat containing natural microbial flora. To prove the applicability of the Tetrazolium Flooding Technique in the presence of a mixed culture, this method was used in an experiment designed to determine the total bacterial count of a low contamination food product; namely, precooked frozen turkey.

Samples of turkey meat weighing 11 g were placed in a blender cup together with 99 ml of chilled sterile water and ground for 4 min. Plate cultures were made of the resulting slurries (1:10 dilution) and the next higher dilution (1:100 dilution). The plating medium used was Plate Count agar (Difco). After the medium solidified the plates were inverted and incubated at 30° C for 36 to 48 hr. The Petri dishes were then removed from the incubator and the distinguishable colonies were counted using a Quebec Colony Counter. The plates were then subjected to the Tetrazolium Flooding Technique after which they were again counted. The two sets of data were compared and the per cent of difference was determined.

RESULTS AND DISCUSSION

The usefulness of the Tetrazolium Flooding Technique was shown dramatically in the experiment designed to determine sterility in chicken muscle. Prior to the flooding procedure, not one colony was visible on any of the 8 Petri dishes. After the Tetrazolium Flooding Technique was performed and the plates were recounted, an average count of 3.5 colonies per plate was obtained. This amounted to 2.4 organisms per gram of original sample. To obtain such information in so short a time would be almost impossible by any other means. Normally, the sample would have been subcultured for a time period at least equivalent to that employed for this entire experiment and would then require plating and further incubation to determine the presence of the contamination. The results obtained by the subculture method would be only qualitative, whereas those obtained through the use of the Tetrazolium Flooding Technique were both qualitative and quantitative.

The improved accuracy made possible by use of the Tetrazolium Flooding Technique was clearly illustrated in the inoculated chicken meat samples. The results shown in Table 1 indicate that bacterial counts, after employment of the technique, were higher in every case.

TABLE I

Plates of chicken samples inoculated with Escherchia coli before and after treatment with 2, 3, 5 triphenyltetrazolium chloride (TPTZ)

Dilution	Number of Petri dishes	Number of colonies observed prior to flooding with TPTZ	Number of colonies observed 3–5 hr after flooding	Per cent difference[1]
10^{-1}	2	413	458	9.8
10^{-2}	1	48	76	36.8
10^{-3}	2	414	473	12.5
10^{-4}	2	619	646	4.2
10^{-5}	2	132	189	30.2
10^{-6}	4	869	934	7.0

[1] $\frac{\text{Number after treatment—Number before treatment}}{\text{Number after treatment}} \times 100$

Before the Tetrazolium Flooding Technique could be applied to the estimation of total bacterial count in a typical food testing situation, information was required to learn whether all microorganisms reduce the indicator solution and whether food products reduce the indicator solution.

Weinberg *(10)* tested 64 strains of *Pseudomonas, Aerobacter, Escherichia, Klebsiella, Salmonella, Alkaligenes, Shigella, Proteus, Erwinia, Rhizobium,* and *Chromobacterium* for their ability to reduce 2,3,5 triphenyltetrazolium chloride to its red formazan form and found that all were capable of performing the reduction. All of the organisms tested in this laboratory reduced the indicator solution. Among these were *Salmonella pullorum, E. coli, Staphylococcus aureus, Streptococcus faecalis, Bacillus subtilis,* and *Clostridium sporogenes.* The wide range of organisms which reduced the tetrazolium salt suggested the possibility that all microorganisms were capable of performing the reduction. Broitman *(2)* and Fifield and Hoff *(4)* reported that some colonies did not turn red when grown in the presence of 2,3,5 triphenyltetrazolium chloride. There are several possible explanations for the apparent disagreement. Weinberg *(10)* reported that organisms growing in a medium containing 2,3,5 triphenyltetrazolium chloride in concentrations less than a particular critical one, failed to produce a red color. Eidus *et al (3)* showed that dead bacteria remained unstained when exposed to tetrazolium. Observations made during these experiments showed that an extended period was required for the reduction of the indicator when a large number of colonies were present on a plate. If the plate

was very crowded (5000 + colonies) no reduction occurred. Very large colonies and colonies on plates which were incubated for an excessive amount of time, reduced the indicator slowly or not at all. The reduced rate or the absence of reduction appeared to be the result of a decreased metabolic rate which may be attributed to the exhaustion of nutrients in the growth medium. Thus, the bacterial colonies which failed to reduce the indicator may have been of a type which was not studied and which actually does not possess a mechanism which reduces tetrazolium, or the concentration of tetrazolium may have been insufficient, or the metabolic functions of the organism may have been reduced below some critical level.

The data reported in Table 2 show that there were colonies present on the Petri dishes of the flounder skin experiments, which were incapable of reducing the indicator solution. Due to the low incubation temperature and the long incubation time used, the Tetrazolium Flooding Technique was subjected to a severe test in these experiments. The results in Table 2 show that the average number of colonies remaining unstained was in the order of 2%. When this value is compared with the per cent difference obtained in the experiments in which food particles were present (see Tables 1 and 3) it becomes relatively insignificant. The gain in accuracy was always greater than the 2% error which might be introduced by the unstained colonies.

TABLE 2

Plates of flounder skin samples, at 10^{-5}, 10^{-6} or 10^{-7} dilutions, before and after treatment with 2, 3, 5 triphenyltetrazolium chloride (TPTZ)

Number of Petri dishes	Number of colonies observed prior to flooding with TPTZ	Number of colored colonies 3–5 hr after flooding	Number of uncolored colonies 3–5 hr after flooding	Per cent uncolored[1]
8	268	264	4	1.5
8	407	408	1	0.2
7	518	525	16	2.9
8	346	357	11	3.0
4	162	159	3	1.9
Total 35	1701	1713	35	Ave. 2.0

[1] $\frac{\text{Number uncolored}}{\text{Number colored + Number uncolored}} \times 100$

In several of the experiments reported in Table 2 the Tetrazolium Flooding Technique resulted in slightly increased counts due to colonies obscured because of their size or position in the plates, but which became readily visible after the color reaction took place.

The oxidation-reduction potential of 2,3,5 triphenyltetrazolium chloride is such that autoclaving, boiling to drive off all the oxygen, or subjection to a high vacuum such as may be achieved mechanically, results in its spontaneous reduction to the red formazan form. Food products are seldom capable of achieving such a reduced state unless aided by a treatment or process. Among the foods screened in this laboratory were canned peas, canned carrots, flour, dried egg solids, corn starch, raw apple slices, and bologna. None of these was capable of reducing the 2,3,5 triphenyltetrazolium chloride during a 5-hr exposure period at room temperature. Because of the somewhat remote possibility that a food product may be capable of spontaneously reducing the indicator, it is recommended that individual products be tested by the investigator prior to use of the Tetrazolium Flooding Technique.

As a final proof of the applicability of the Tetrazolium Flooding Technique to obtain more accurate estimates of total bacterial count in a food product of low bacterial contamination, an actual food product, pre-cooked frozen turkey meat, was selected and a standard plate count procedure was performed. The Tetrazolium Flooding Technique was then incorporated into the procedure and the results of the experiment prior to and after the treatment are presented in Table 3. In every case except one, there was an increase in colonies detected after the treatment as a result of hidden colonies becoming clearly visible. The one exception was in a low count plate on which 4 pieces of turkey meat were mistakenly identified as bacterial colonies prior to the tetrazolium treatment. The differences observed varied from 10.4% to 26.6%. The value of the Tetrazolium Flooding Technique in providing more correct estimates of the total count was again illustrated.

TABLE 3

Plates of pre-cooked frozen turkey samples counted before and after treatment with 2, 3, 5 triphenyltetrazolium chloride (TPTZ)

Dilution	Estimated no of colonies prior to flooding with TPTZ	No of colored colonies 3 hrs after flooding with TPTZ	Per cent difference[1]
10^{-2}	62	76	+19.7
10^{-2}	67	87	+23.0
10^{-2}	117	158	+25.9
10^{-2}	130	177	+26.6
10^{-2}	95	106	+10.4
10^{-2}	100	118	+15.2
10^{-1}	26	31	+16.1
10^{-1}	20	16	−25.0

[1] $\frac{\text{Number after treatment—Number before treatment}}{\text{Number after treatment}} \times 100$

There is another source of error which could be introduced into an experiment by the use of the Tetrazolium Flooding Technique. This was not troublesome in the experiments herein reported due to the availability of low relative humidity (30% to 55%) incubation chambers. If higher humidity incubators were used a few colonies might be floated off the surface of the culture medium during the addition and spreading of the indicator solution. This may be minimized through the exercise of great care and may be eliminated by overlaying the poured plate with a thin layer of agar prior to incubation using a technique similar to that employed when pouring desoxycholate agar plates for coliform counts in accordance with *Standard Methods for the Examination of Dairy Products (8)*.

The incubation time, when the Tetrazolium Flooding Technique is employed, should be reduced to approximately 80% of that required when performing a standard plate count. This reduction will result in culture plates containing more actively metabolizing

colonies which will reduce the 2,3,5 triphenyltetrazolium chloride rapidly.

SUMMARY AND CONCLUSIONS

The Tetrazolium Flooding Technique offers investigators in the food field an opportunity to obtain more accurate estimates of actual numbers of bacteria present in many food products of low bacterial count. The data of Ziegler and Halvorson *(11)* illustrated the superiority of the plate count method over the serial dilution method when accuracy was desired. The reported technique allows extension of the range in which the standard plate count may be employed. This advantage more than compensates for the two new sources of error, unstained colonies and floated off colonies, which might be introduced into an experiment through employment of this technique.

The Tetrazolium Flooding Technique also provides a means whereby incubation time may be reduced since small colonies become readily visible upon agar plates.

Use of the tetrazolium flooding method for quantitative sterility testing in pureed food products as well as in solid food products appears possible.

The technique has many possible applications in research and quality control laboratories. The investigator must not, however, lose sight of the limitations of the method. The technique was tested in a few specific situations during this study and therefore should not be applied universally without additional testing. The factors which must be determined prior to adaptation of the Tetrazolium Flooding Technique to a procedure include: the suitability of the product, the suitability of the bacterial population, and the proper adjustment of standard incubation times.

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LITERATURE CITED

1. Angelotti, R., Foter, M. J., Busch, K. A., and Lewis, K. H. A comparative evaluation of methods for determining the bacterial contamination of surfaces. *Food Research*, **23**, 175 (1958).
2. Broitman, S. A. Methods for estimating the psychrophilic populations and keeping quality of milk. (Ph.D. thesis, Michigan State University, 1956).
3. Eidus, L., Diena, B. B., and Greenberg, L. Observations on the use of tetrazolium salts in the vital staining of bacteria. *Can J. Microbiol.*, **5**, 245 (1959).
4. Fifield, C. W., and Hoff, J. E. Dilute malachite green: A background stain for the millipore filter. *Stain Technol.*, **32** (2) 95 (1957).
5. Goetz, A., and Tsuneishi, N. Application of molecular membranes to the bacteriological analysis of water. *J. Am. Water Works Ass'n*, **43**, 943 (1951).
6. Proctor, B. E., Nickerson, J. T. R., Fazzina, T. L., Ronsivalli, L., Smith, R. K., and Stern, J. Rapid determination of the quality of whole eviscerated haddock. *Food Technol.*, **13**, 224 (1959).
7. *Recommended Methods for the Microbiological Examination of Foods.* 1958. Publication Office, American Public Health Association, Inc., 1790 Broadway, New York 19, N. Y.
8. *Standard Methods for the Examination of Dairy Products.* 10th ed. 1953. American Public Health Association, Inc., 1790 Broadway, New York 19, New York. p. 144.
9. Weibull, C. Observations on the staining of *Bacillus megaterium* with triphenyltetrazolium. *J. Bacteriol.*, **66**, 137 (1953).
10. Weinberg, E. D. Selective inhibition of microbial growth by the incorporation of triphenyltetrazolium chloride in culture media. *J. Bacteriol.*, **66**, 240 (1953).
11. Ziegler, N. R., and Halvorson, H. O. Application of statistics to problems in bacteriology. *J. Bacteriol.*, **29**, 609 (1935).

Factors Affecting the Drained Weight and Firmness of Red Tart Cherries[a, b]

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SINCE RED TART CHERRIES are consumed largely in baked goods, the baker as well as the processor is concerned with drained weight and firmness. Drained weight, a measure of the usable solid portion of the pack, largely determines the yield of pies. Since firm cherries will remain plump during baking, firmness is a most desirable quality in cherries from the baker's point of view. The processor is directly concerned with both of these factors, too. Soft fruit may lose excessive juice during pitting, causing low case yield, or become excessively pitter-torn and flabby, resulting in a low score for character under the U. S. Grade.

To promote the firming of cherries that are bruised and softened by harvest handling, the processor usually soaks the fruit in cold water for 2 to 24 hours before pitting. The conditioned cherries are better able to withstand pitting without excessive tearing or juice loss, and they subsequently produce a plump, firm-fleshed product with a high drained weight. This study has been concerned with those conditions between picking and pitting that influence the firming process.

A number of previous studies have been made with results which are notably conflicting. Early and persistent views ascribed the firming of cherries to soaking *(6, 10)*, to chilling *(9, 12, 13)*, or to both *(4)*. More recently a greater appreciation of the role of time in increasing drained weight and firmness has developed *(1, 2, 9, 11, 13)*. In addition, holding in air has been found on occasion to give equally as much firming as soaking in water *(2, 12)*. Fruit maturity has been variously reported to have no effect on drained weight *(7)*, and to impart low drained weight in early harvest cherries *(9)*. Even the idea that cooling promoted firming has been upset by observations that firming progresses more rapidly in the absence of chilling *(7)* and at elevated frozen storage temperatures *(1)*. However, work by Whittenberger and others *(7, 11, 12, 13)* has consistently shown that firming follows bruising under various conditions, resulting in both firmer flesh and higher drained weights.

EXPERIMENTAL

The firming of red tart cherries in the interval between picking and pitting was observed under various conditions in 1955 and 1956. The effects of time, temperature, bruising, and holding in air versus soaking in water were investigated. The use of a harvest sequence also permitted the effect of fruit maturity to be observed.

During the 1955 season a series of 9 experimental lots was used to compare the firming of cherries at elapsed times after picking of 0, 3, 6, and 10 hr at 40° F and 0 and 6 hr at 80° F. These lots also included direct comparisons of soaking in water vs holding in air. In 1956 soaking time was studied further to include times of 0, 1, 2½, 4½, 7 and 9¾ hr at 45° F. In each case, to the nominal elapsed time of holding or soaking must be added the half-hour required to harvest the fruit and transport it to the processing facilities. Another study in 1956 compared unbruised fruit, picked by and with stems, with normally- and badly-bruised cherries.

Montmorency cherries were obtained from a young orchard[c] only a half-mile distant from the pilot plant processing facilities. In each experiment the several 30-lb lots, to be subjected to a series of processing conditions, were picked in sequence from a group of 5 trees. This allowed the picking time to be specific to within 7 min while holding the source of fruit constant. The 6-lb fractions from each tree were picked non-selectively from a narrow wedge section so as to represent adequately the prevailing maturity of the fruit. Cherries were harvested and processed weekly, repeating at each harvest the same series of experimental conditions. This was done both to determine the effect of harvest date and to avoid the error of basing results on some arbitrarily chosen fruit maturity. Rather, we obtained an average over the harvest season.

In order to insure uniformity of bruising throughout the experiments, selected personnel performed the picking. The resulting moderate degree of bruising was then augmented within a half-hour after harvest by pouring the fruit once from a height of 30 inches in a special jig onto a slanting, self-cleaning surface. The two degrees of bruising studied were obtained by omitting this extra bruise in one lot and repeating it twice in the other.

The proximity of the orchard allowed the unavoidable hold time between picking and further processing to be reduced to one-half hour. It was a matter of considerable importance to minimize this lag in these experiments. The desired holding temperatures were attained soon after harvest by carefully spreading the cherries out in trays in the proper environment.

Soaking was accomplished in a series of six 10-gallon tanks modeled after commercial tanks with bottom-mounted manifolds. Water was recirculated from the tank overflows through a refrigerating system to these manifolds. Soak temperature was thermostatically controlled in each tank and monitored through thermocouples by a recording potentiometer. Thermostatically-controlled rooms were used for holding in air at 40 and 80° F. After holding or soaking, the cherries were sorted on a white conveyor belt under a MacBeth Examolite and pitted in a Dunkley small mechanical pitter of 300 lb per hour capacity.

The accurate evaluation of drained weight depends in part on careful packing of the fruit. Since considerable juice separates from the cherries during and immediately after pitting, the extent to which the fruit is drained and the ratio of juice to fruit in the pack must be precisely controlled, particularly in the frozen pack. To meet these requirements the pitter was first rinsed with water and allowed to drain 2 min before pitting. Directly after pitting the cherries were drained in a 3-inch layer on a 4-mesh screen for 5 min. An aliquot of this

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 27, 1958, Chicago.

[b] Approved by the Director of the New York State Agricultural Experiment Station as Journal Paper No. 1217, April 8, 1960.

[c] Located on the Experiment Station tract.

drained juice was then added to each No. 2 can packed as a proportional part of the normal fill-in weight of 450 g.

Packing of cherries to be frozen was completed by adding dry sugar to the fruit in the ratio of 1:5. The sugar and juice aliquot were filled into the bottom of the can and the cans were inverted during freezing to dissolve and distribute the sugar. The freezing was accomplished in still air at 0° F. Hot-packed cherries were covered with water at 160° F, exhausted for 10 min in a 180° F agitated bath, closed with mechanical vacuum, retorted for 12 min at 211° F, and finally cooled in running tap (70° F) water. Twelve No. 2 cans were packed for each lot, 6 for hot-pack and 6 for freezing. Storage temperature for the frozen and canned products were 0 and 75° F, respectively.

Firmness of freshly-pitted cherries was measured in terms of resistance to compression. This was accomplished indirectly by determination of the bulk density of pitted fruit in an ordinary 10-lb fruit can. The can was filled level-full with cherries in a close-packed arrangement by tapping the can on a hard surface while filling until settling of the fruit ceased. The pitted fruit deforms under its own weight, reducing interstitial voids in proportion to its firmness or resistance to compression. Soft fruit deforms the most, increasing the weight of fruit occupying the can volume of 0.184 cubic feet. Procedural error is due mainly to the operator's concept of level-full, while sampling error is small since the 11-lb sample constitutes about half the experimental lot.

Both frozen and canned samples were graded by Processed Products Inspectors of the U.S.D.A. Three cans of product from each lot were inspected after 3 months' storage and 3 more after 10 months. Subjective scores for character (principally firmness) and color were assigned and counts were made of pitter-torn and of scalded cherries. A scald index was calculated by weighting moderately and seriously scalded cherries one and two, respectively.

In this paper drained weight is expressed as the per cent of put-in weight of cherries, juice, and sugar which is retained on the drainage sieve. A drained weight was determined on these same samples just prior to inspection. The procedure for taking drained weights of the frozen product, which is not described in the U. S. Grade, was as follows: The cans of fruit were first brought to a fairly uniform temperature by thawing in pails of water in a room at 40° F. Within 6 hours the cans became encased in ice and remained close to the 32° F level throughout the period of inspection. Samples were broken out of the ice as used so that the temperature of the fruit just before dumping on the screen ranged from 28° to 35° F. This temperature control increases the precision of the drained weight determination. The fruit from the No. 2 cans was drained on standard 8-inch, 8-mesh screens for 2 min.

Statistical analysis. The data were subjected to analysis of variance in 3 separate sets, the 9 treatment × 4 harvest set from 1955 and both a 6 treatment × 3 harvest set and a 3 treatment × 3 harvest set from 1956. Interactions, none of which was significant, were lumped in the error variance. *F* values were first inspected for presence of significant differences among treatments and harvest. The least significant differences (LSD) for treatment and harvest means were then calculated using Duncan's new multiple range test *(3)*. This method of comparing a series of means compensates for the use of "t" in the comparison of more than two treatment means. The method, in recognition of the impracticability of maintaining a protection level of 95% in multiple comparisons of the type encountered here, both increases the LSD, and lowers the protection level. Corrections are applied only to prevent the protection level from falling below certain limits, which are $(N+1)$ powers of 0.95, when comparing means separated by N places in the range. Use of this method here increases the normal LSD's by approximately 10%, in comparing the extremes in a set of 6 data, and by 15% in a set of 9 data.

RESULTS

Soaking time. During the 1956 season a decided increase in both drained weight and firmness occurred as soaking time was prolonged, as shown in Table 1. The per cent drained juice, bulk density of pitted fruit, and per cent pitter-torn cherries all decreased; drained weight and character scores of both frozen and canned products improved. The trends are all similar in exhibiting reduced rates of change as soaking time is prolonged. However, in several of these only a minimal reversed trend is apparent in the first hour with maximum rate of change occurring between 1 and 2½ hr. This is not presently understood and may be due to some inadequacy in procedure.

TABLE 1

Effect of time on the drained weight and firmness of cherries soaked at 45° F. Data are averages of three lots harvested at weekly intervals in 1956

	Soak time, hours					
	0	1	2½	4½	7	9¾
Juice drained after pitting, %	15.4	13.4	11.9	9.9	9.1	8.5
Bulk density, pitted fruit, kg/10-lb can	4.97	4.97	4.89	4.83	4.80	4.75
Drained weight, %						
Frozen	89.7	89.4	90.8	92.4	93.4	94.0
Canned	80.3	82.0	83.5	84.1	85.6	86.4
Pitter-torn cherries, %						
Frozen	4.2	5.2	2.2	2.2	1.7	1.8
Canned	5.2	6.7	2.9	2.9	2.2	2.1
Character score						
Frozen	31.4	32.6	33.7	33.6	34.0	34.4
Canned	32.8	33.4	34.6	34.2	34.9	34.5

Data underlined do not differ significantly at the 5% level.

Data in Table 1 are presented in such a manner that the significant differences may be readily seen. Data linked by underlining do not differ significantly at the 5% level. For each parameter measured and presented in the table, the extremes at least in the observed trends are significantly different at this level. Moreover, the frequent occurrence of such differences in the interval 1–2½ hours is very apparent, suggesting that the maximal rate of change may be occurring at that particular time.

Data in Table 2 from the 1955 season substantiate the increases in drained weight and firmness with extended soak time which have just been demonstrated. Per cent drained juice, bulk density, and per cent pitter-torn cherries all decreased as either hold or soak time was prolonged; drained weight and character score increased. Each trend also shows a higher rate of change in the first 3 hours, as before. The underlining of data in Table 2 again calls attention to the significant differences occurring in each quality factor in this first interval.

Holding in air vs soaking in water. A direct comparison of holding cherries in air vs soaking them in water demonstrates

TABLE 2

Comparison of cherries held in air or soaked in water at 40° F, for periods ranging from 0–10 hours. Data are averages of four lots harvested at weekly intervals in 1955

	D1 0 hours	D2 3 hours soak	D3 6 hours soak	D4 6 hours hold	D5 10 hours soak	D6 10 hours hold	L.S.M.D. 5%
Juice drained after pitting, %	19.9	13.8	12.7	12.1	10.1	9.9	1.8
Bulk density of pitted fruit, kg/10-lb can	5.10	4.87	4.82	4.82	4.70	4.73	0.10
Drained weight, %							
Frozen	89.9	92.0	93.3	93.7	92.7	93.6	2.1
Canned	80.8	85.6	85.7	86.3	86.6	89.3	2.0
Pitter-torn cherries, %							
Frozen	9.8	4.9	4.8	3.4	1.8	1.9	3.0
Canned	9.0	4.3	4.9	5.5	2.3	1.9	3.9
Character score							
Frozen	27.7	33.3	31.8	32.8	33.4	33.8	2.8
Canned	28.4	32.2	31.8	32.3	34.1	34.5	2.6

Data underlined do not differ significantly at the 5% level.

TABLE 3

Comparison of cherries held in air or soaked in water for six hours at 40° and 80° F. Data are averages of four lots harvested at weekly intervals in 1955

	6-hour soak in water				6-hour hold in air			
	D3 40° F	D9 80° F	Δ[1]	L.S.D. 5%	D5 40° F	D8 80° F	Δ[1]	L.S.D. 5%
Juice drained after pitting, %	12.7	13.2	0.5	1.9	12.1	12.8	0.7	1.9
Bulk density pitted fruit, kg/10 lb can	4.82	4.77	0.5	0.10	4.82	4.76	0.6	0.10
Drained weight, %								
Frozen	93.3	92.6	0.7	2.2	93.7	93.9	0.2	2.1
Canned	85.7	85.9	0.2	2.0	86.3	87.3	1.0	2.1
Pitter-torn cherries, %								
Frozen	4.8	2.5	1.7	3.2	3.4	2.0	1.4	3.2
Canned	4.9	2.6	1.7	4.1	5.5	2.1	3.4	4.3
Character Score								
Frozen	31.8	32.9	1.1	3.1	32.8	32.5	0.3	2.8
Canned	31.8	34.3	2.5	3.0	32.3	33.6	1.3	2.6
Color Score								
Frozen	17.8	16.5	1.3*	0.7	17.5	16.9	0.6	0.7
Canned	18.0	17.3	0.7*	0.5	17.8	17.4	0.4	0.5
Scald Index								
Frozen	2.6	10.9	8.3**	2.0	6.3	12.8	6.5**	2.0

[1] Difference—underlining denotes apparent improvement at 40° F.
* Significant at 5% level.
** Significant at 1% level.

that these techniques are roughly equivalent in terms of product firmness. Data in Table 2 show only one significant difference in drained weight where cherries were held or soaked at 40° F for either 6 or 10 hr. Specifically, the juice drained after pitting, the bulk density of the pitted fruit, the per cent of pitter-torn cherries, and the character score are the same for these two processing conditions.

The lone exception lies in the drained weight of the canned product for the 10-hr process. However, note that drained weight is consistently higher for air-held cherries in both canned and frozen products at either 6 or 10 hr, though only significantly so in this one case. The tendency in this direction is not unexpected in view of the slight water uptake experienced in soaking as against the slight desiccation, which occurs during holding in air.

Additional evidence of the equivalence, with respect to firming, of holding in air and soaking in water is found in Table 3, where the comparison is made at 80° F as well as at 40° F. At neither temperature are there significant differences among the quality factors measured.

Temperature. The temperature of hold or soak had little effect on the firmness and drained weight of cherries (Table 3). Significant differences resulting from 6 hr at temperatures of 40° and 80° F were observed only in color scores and in scald index. Differences in drained weight and firmness were generally much smaller than those required for significance. This seems to disprove the contention that chilling promotes firming, particularly since most of the slight differences observed lie in the direction of improved firmness and drained weight at the higher temperature. At least it is clear, as shown in previous work *(8)*, that scald damage is higher at 80° F than at 40° F, resulting in significantly lower color scores and even down-grading of the frozen product.

In order to evaluate directly the influence of temperatures, while reducing the effect of time, chilled and unchilled cherries were pitted within one-half hour after picking. Data in Table 4 show no significant differences between pitting warm or cold cherries with reference to drained weight or firmness. However, a significant difference does appear in the color score of the frozen product. Apparently the failure to chill the fruit before pitting allows some scald to develop in the fruit after packing, before the contents of the can cool sufficiently to prevent it.

Bruising. In a comparison of three degrees of bruising, significant differences in firmness were found mainly between the badly-bruised and either unbruised or normally-bruised fruit.

TABLE 4

Comparison of cherries chilled (40° F) before pitting with those pitted at orchard temperature (80° F). The data are averages of four lots harvested at weekly intervals in 1955

Objective test of quality	D1 40° F	D7 80° F	Difference, D1–D7	L.S.M.D. 5%
Juice drained after pitting, %	19.9	18.5	+1.4	1.8
Bulk density of pitted fruit, kg/10 lb can	5.10	5.10	0	0.10
Drained weight, %				
Frozen	89.9	90.5	−0.6	2.1
Canned	80.8	82.5	−1.7	2.0
Pitter-torn cherries, %				
Frozen	9.8	8.0	+1.8	3.0
Canned	9.0	8.0	+1.0	3.9
Character score				
Frozen	27.7	28.4	−0.7	2.8
Canned	28.4	28.0	+0.4	2.6
Color score				
Frozen	18.5	17.8	+0.7*	0.7
Canned	17.6	17.3	+0.3	0.5
Scald Index				
Frozen	1.4	2.4	−1.0	1.8

* Significant at 5% level.
Differences underlined indicate apparent improvement in quality at 40° F.

No difference resulted from the lesser degrees of bruising (Table 5). The badly bruised fruit had higher drained weight in the frozen product and fewer pitter-torn cherries in both canned and frozen products than cherries bruised to a lesser extent. On the other hand, the badly-bruised cherries also had a significantly lower color score in the frozen product, probably as a consequence of the higher scald index.

Harvest date. Fruit maturity, or harvest date, had a decided effect on firmness and drained weight, as shown in Table 6. Cherries became progressively softer and more juicy as they ripened. Increases occurred in juice drained after pitting, bulk density, and pitter-torn cherries while drained weight and character score diminished as the fruit matured. Significant changes were noted in each parameter measured, but they are found most frequently between the first two weekly harvests. This suggests that changes occur most rapidly in the cherries early in the harvest season.

TABLE 5

Effect of bruising on the drained weight and firmness of cherries soaked 5½ hours at 50° F. Data are averages of three lots harvested at weekly intervals in 1956

	Degrees of bruise			L.S.D. %
	Unbruised	Normally bruised	Badly bruised	
Juice drained after pitting, %	9.9	10.1	10.0	....
Bulk density of pitted fruit, kg/10-lb can	4.78	4.76	4.82	0.10
Drained weight, %				
Frozen	90.9	92.0	93.5	2.1
Canned	82.6	83.6	86.1	3.0
Pitter-torn cherries, %				
Frozen	3.5	3.3	2.2	0.9
Canned	2.8	2.3	1.6	2.0
Character score				
Frozen	33.6	33.3	33.2	2.0
Canned	33.2	33.5	34.9	3.5
Color score				
Frozen	17.5	16.7	15.7	1.3
Canned	17.3	17.0	17.3	....
Scald Index				
Frozen	4.7	8.7	12.3	8.5

Data underlined do not differ significantly at the 5% level.

DISCUSSION

The increases in firmness and drained weight observed in this study, in connection with prolonged holding or soaking and particularly in bruised fruit, establish that from a practical standpoint firming of cherries after harvest does occur. This firming, or toughening, of cherries in the interval between picking and pitting has been observed by other investigators and ascribed to an actual repair or recovery of the bruised tissue *(11)*. This repair is further described as both a strengthening of the intercellular cement and a thickening of the cell walls. More recently it has been suggested that the enzymic deesterification of pectic substances may be involved in a similar toughening of frozen cherries held at 20° F or higher *(4)*.

Other explanations of the post-harvest firming of cherries have emphasized the necessity of chilling the fruit, although no suggestion has been made of what physiological mechanism, other than increase in turgor, might be responsible for firming. Although it is true that increased turgor is usually associated with soaking in cold water, probably because of water uptake, this has little influence on the final firmness of the pitted product. At most there may be a tendency for the pitting needles to cut through the skin of turgid cherries more cleanly. The experiments described here, however, fail to demonstrate any effect of temperature alone.

Conclusive evidence has been presented that the toughening of cherries occurs as readily in air as in water, contrary to the prevalent belief in the industry that soaking is required. An increase in turgor when cherries are soaked vs a slight desiccation and loss of turgor when they are held in air may account for the common association of firming with soaking. However, as has been pointed out, turgid cherries are not necessarily tough-fleshed. Drained weight may even be improved by the partial desiccation experienced in air-holding, although at the probable expense of processing yield.

It has been suggested that cherries bruised just enough to spontaneously undergo the toughening process may actually provide a firmer product than that from unbruised fruit. This was partly borne out by the improvements in drained weight and pitter-tear experienced with badly bruised cherries in the present tests. Product bulk density and character score showed no improvement, however. Moreover, any advantage was more than offset by the deterioration of color due to scald and oxidation in the bruised fruit. It must also be remembered that fruit which is "mashed" as opposed to merely bruised will make no such recovery. Certainly, cherries are ordinarily bruised enough to promote both the desired firming and undesirable scald.

The softening of cherries observed during ripening is of considerable importance to the processor. Not only does it adversely affect character and drained weight of the processed product, but it may render the fruit more susceptible to bruising. This may intensify scald damage just as the difficulty experienced in separating cherries from their stems results in increased bruising and scald early in the harvest.

A critical look at the determination of drained weight is now in order. It is apparent that the technique of adding an aliquot of the juice drained after pitting to each can of cherries causes the drained weights in this study to follow the trends established by the drained juice quite closely. However, if the drained weights are calculated on the basis of the put-in weight of cherries only—without juice—an interesting turnabout is observed (Table 7).

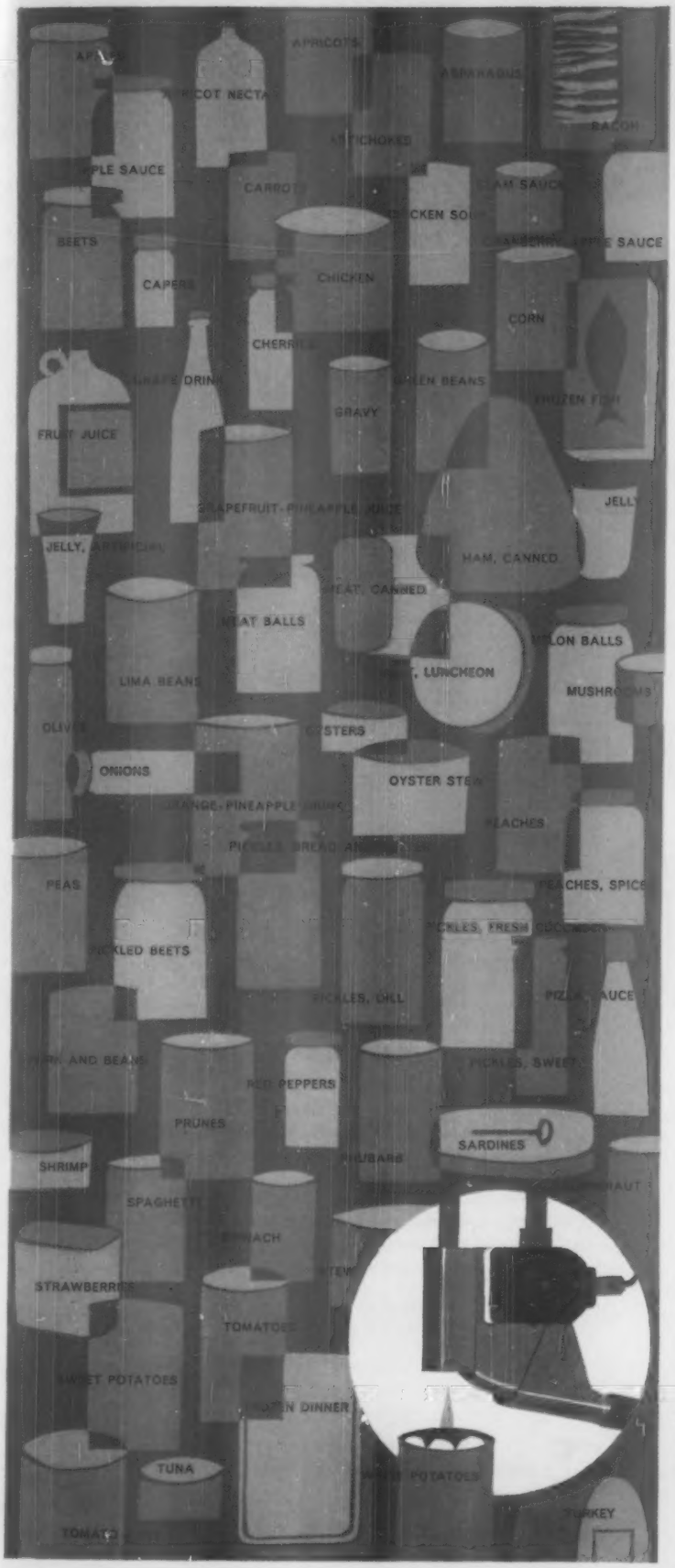
Calculated in this manner the drained weights now appear inversely proportional to processing time, reversing the trend observed in Table 2. Moreover, the differences among 0, 6, and 10 hr holding or soaking time are decidedly significant. This indicates that cherries which bleed excessively right after pitting lose proportionately less juice when the processed product is drained. This does not invalidate the conclusions of this report relative to drained weight, but it may explain the disagreement with previously re-

TABLE 6

Changes in the drained weight and firmness of cherries harvested at weekly intervals during 1955. Data are averages of nine lots representing various processing conditions

	Harvest date				L.S.D. %
	7/11	7/18	7/25	8/1	
Juice drained after pitting, %	10.0	13.6	14.6	16.5	1.2
Bulk density of pitted fruit, kg/10-lb can	4.67	4.78	4.91	5.05	0.10
Drained weight, %					
Frozen	95.4	92.4	90.5	91.5	1.4
Canned	88.4	85.4	83.3	85.1	1.3
Pitter-torn cherries, %					
Frozen	1.8	4.8	5.7	4.9	2.0
Canned	2.3	3.9	5.4	6.0	2.6
Character score					
Frozen	34.0	32.5	30.3	30.4	1.9
Canned	34.5	32.1	31.2	30.7	1.8

Data underlined do not differ significantly at the 5% level.



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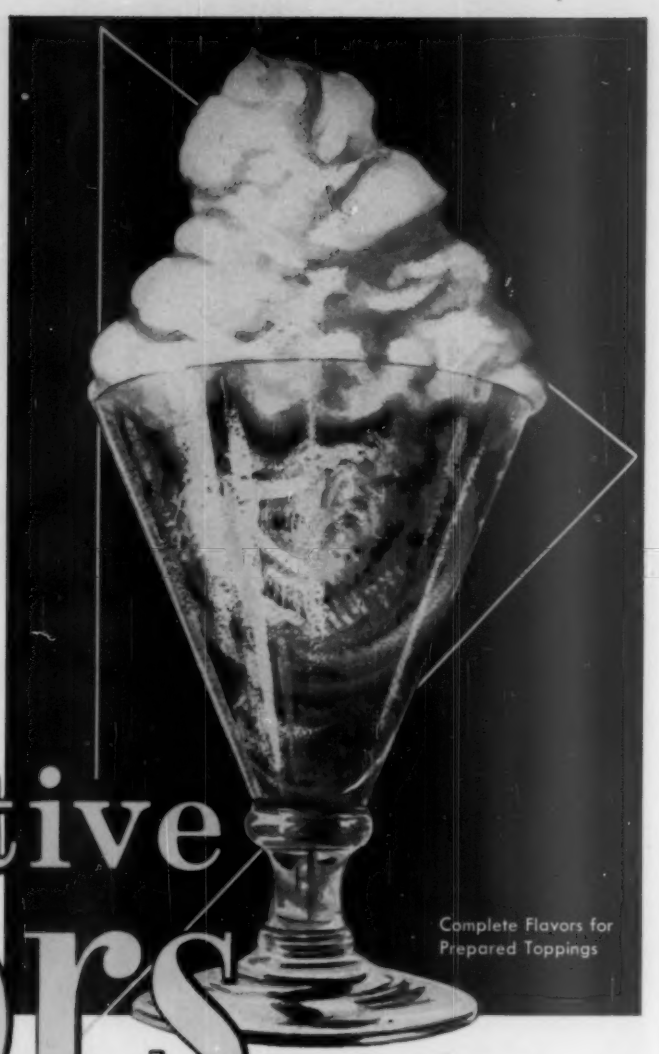

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TABLE 7

Drained weights based on put-in weight of cherries alone, without juice

	D4	D6	D2	D5	D9	D3	D8	D7	D1
Hold or Soak									
Time, hours	10	10	3	6	6	6	6	0	0
Temp, °F	40	40	40	40	80	40	80	80	40
Drained weight, frozen, %	103.2	103.9	106.6	106.6	106.6	106.8	107.7	111.2	112.3

Data underlined do not differ significantly at the 5% level.

ported results of other observers. It is evident that whether a positive, negative, or inconclusive result is obtained when the effect of a treatment on drained weight is being investigated will depend on the proportion of juice which is actually lost at the pitter and not incorporated in the product as part of the fill-in weight. The results reported in this paper were obtained with minimum juice loss and must be considered in that light. Otherwise differences in drained weight might have been outweighed by considerable differences in yield. The juice-loss experienced in commercial practice may be moderate to heavy, probably somewhere in between the extremes examined here. It is not clear whether, in normal commercial experience, drained weight suffers from pitting too promptly after picking or not. This depends entirely on the juice loss permitted in the equipment. It is clear, though, that if drained weight is not low, then yield is.

Considerable success was experienced in measuring the firmness of freshly-pitted cherries by means of bulk density. Significant differences were readily obtained among treatments and harvests, and the trends observed were in agreement with character scores of the final product. Bulk density is actually a measure of the resistance to compression of the pitted cherry, free of the misleading balloon-like turgor of the unpitted fruit. Since it readily measures a large sample with simple equipment, the procedure may be well adapted for on-the-line quality control. However, consistent results do require careful technique by the operator.

The conflicting demands of color and flavor on the one hand, and of firmness and drained weight on the other must be emphasized. Color and flavor are enhanced by processing unbruised fruit rapidly and at a low temperature. However, firmness and drained weight may be improved by prolonged aging of bruised fruit without the need of chilling. The processing of red tart cherries therefore involves a compromise between these requirements to obtain the best over-all quality. In practice this compromise process should prevent excessive damage of the fresh fruit during picking and subsequent handling, encourage prompt chilling to 40–50° F, and limit the combined holding and soaking period to a total of 4 to 10 hr. For the frozen product low packing temperature and rapid freezing are additional requirements.

SUMMARY

Factors which have been found to influence the firmness and drained weight of frozen or canned cherries are time elapsed between harvest and packing, degree of bruising, and fruit maturity. Prolonged holding time provides progressively higher character scores and drained weights in the processed products, whereas the ripening of the fruit has the opposite effects. Although bruising also tends to augment firmness in the final product, it has the disadvantage of promoting decidedly greater scald.

No difference was found between the firming effects of holding in air as compared to soaking in water. Neither were any significant differences in firmness observed when holding or soaking temperatures of 40 and 80° F were compared. The higher temperature merely encouraged scald damage.

In general, conditions which favor high drained weight and firmness in red tart cherries are also conducive to scald and adversely affect color. As a compromise between these two quality objectives, it is suggested that cherries be handled with minimal bruising and be promptly chilled and soaked in cold water for moderate periods of 4 to 10 hours.

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LITERATURE CITED

1. Bedford, C. L., and Robertson, W. F. The effect of various factors on the drained weight of canned red cherries. *Food Technol.*, **9**, 321 (1955).
2. Bedford, C. L., and Robertson, W. F. Effect of handling and processing methods on the firmness and quality of canned and frozen red cherries. *Quart. Bull. Mich. Agr. Expt. Station*, **40** (1) 51 (1957).
3. Duncan, D. B. Multiple range and multiple F tests. *Biometrics*, **11**, 1 (1955).
4. Gee, M., and McCready, R. M. Texture changes in frozen Montmorency cherries. *Food Research*, 22, 300 (1957).
5. Gould, W. A. Assures cherry quality with 6-point check-up. *Food Packer*, **32** (7) 32 (1951).
6. Griswold, R. M. Factors influencing the quality of home-canned Montmorency cherries. *Michigan Agr. Exp. Sta. Tech. Bull.*, **194** (1944).
7. Hills, C. H., Whittenberger, R. T., Robertson, W. F., and Case, W. H. Studies on the processing of red cherries. II. Some effects of bruising on the yield and quality of canned Montmorency cherries. *Food Technol.*, **7**, 32 (1953).

8. LaBelle, R. L., Moyer, J. C., Robinson, W. B., and Hand, D. B. Causes of scald in red tart cherries. *Food Technol.*, 12, 94 (1958).
9. Marshall, R. E., Robertson, W. F., Bedford, C. L., and Case, W. H. The effect of the length of soak on the quality of canned and frozen Montmorency cherries. *Food Technol.*, 5, 116 (1951).
10. Peterson, G. T. Changes in sour cherries resulting from soaking. *Fruit Products J.*, 17, 172 (1938).
11. Whittenberger, R. T. Factors which affect the drained weight and other characteristics of heat processed red cherries. *Food Research*, 17, 299 (1952).
12. Whittenberger, R. T., and Hills, C. H. Studies on the processing of red cherries. I. Changes in fresh red cherries caused by bruising, cooling, and soaking. *Food Technol.*, 7, 29 (1953).
13. Whittenberger, R. T., and Marshall, R. E. Measuring firmness of red tart cherries. *Food Technol.*, 4, 311 (1950).

Effects of Sulfur Dioxide, Temperature, Time, and Closures on the Quality of Bottled Dry White Table Wines

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The shelf storage life of many unfortified dry white table wines depends primarily on the effectiveness of pre-bottling pasteurization or the amount of free sulfur dioxide retained during storage. Few wines are sterile when ready to bottle. To ensure biological stability, wineries either pasteurize or add relatively large amounts of sulfur dioxide. Either method enhances biological stability, but can add off-flavors.

When added to wine, sulfur dioxide combines with certain sugars and aldehydes to some extent, forming sulfonates. In this combined (fixed) form it is relatively inactive as an inhibitor of yeast or bacterial growth *(9)*. Wines of lower pH values in general require less total sulfur dioxide to maintain an effective level of free sulfur dioxide *(13)*. The role of sulfur dioxide as a microbial agent, antioxidant, and yeast inhibitor has had detailed reviews by Amerine *(2)*, Ingram *(10)*, Joslyn *(11)*, and Joslyn and Braverman *(12)*.

Amerine and Joslyn *(3)* pointed out that reasonable cellar care preceding bottling eliminates a need for excessive amounts of sulfur dioxide. The general tendency is nevertheless to make sure of biological stability by using more sulfur dioxide than necessary. It is questionable whether the fewer wines that cloud on the shelves justify the decrease in wine quality caused by sulfur dioxide above threshold level.

Concentrations of 100 to 150 mg per liter of total sulfur dioxide may be tolerable to wine tasters evaluating dry wines. The literature *(6, 8)* on this subject, however, is not in complete agreement. Amounts greater than this can usually be detected and may be considered detrimental to wine quality.

Screw cap closures for wine bottles have become increasingly common in the last 10 years. This type of closure as presently used is satisfactory *(4)*, despite harm to an occasional wine.

The present experiments were conducted at two sulfur dioxide levels to determine how storage temperature, length of storage, and closure affect the retention of sulfur dioxide in the wine and wine quality as judged by an experienced taste panel.

EXPERIMENTAL

Design. Three series of wines were stored at 4 temperatures with 2 levels of sulfur dioxide concentration (series I and II). These variables as well as 2 closure types were tested (series III).

Storage and temperature. Wines were stored in standard ⅕-gal wine bottles. Storage temperatures were controlled to ±1.0° F for 32°, 53°, and 70° F, and to ±5.0° F for 120° F. The bottles were stored on their sides, ensuring liquid contact with the closures.

Closures. Two types of closures tested were 1¾ in corks (extra first quality, hand cut, no. 9 size) and aluminum metal screw caps with cork and plastic liners. Corks were inserted with a hand corker, and the caps put on with a commercial machine capper. A check was made several days after bottling, and any leaky corks or caps were replaced.

Tastings. Tastings by 8 experienced tasters were conducted after storage for 1, 9, and 22 months. A 20-point scoring system was used (lower value indicates lower quality). Wines were presented in random order and properly coded *(5)*. In a

TABLE 1

Effects of temperature and time on sulfur dioxide concentration in two wines at two sulfur dioxide levels (Series I and II)

Series	Temperature of storage °F	Relative sulfur dioxide level	Total sulfur dioxide mg/l			Free sulfur dioxide mg/l		
			Time of storage (months)			Time of storage (months)		
			1	9	22	1	9	22
I	32	High	241	181	193	135	90	90
	53		224	198	187	112	108	100
	70		210	212	186	112	99	82
	120		212	146	8	84	35	2
	32	Low	95	67	69	14	12	5
	53		92	66	56	14	10	5
	70		78	63	64	9	7	6
	120		73	45	....	9	7	....
II	32	High	254	....	238	150	115	127
	53		248	206	218	139	105	102
	70		246	204	210	128	105	97
	120		223	161	120	102	75	23
	32	Low	100	....	86	35	17	13
	53		92	82	80	21	17	12
	70		85	82	69	14	....	8
	120		75	50	35	11	9	5

separate tasting the panel was asked to rank 8 samples from each series in order of quality.

Analyses. Chemcal analyses were made by the methods of Amerine *(1)*. Standard statistical procedures were used for the analyses of variance. Significant differences between mean scores were determined by the method developed by Duncan *(7)*.

RESULTS AND DISCUSSION

Total and free sulfur dioxide determinations for the first 2 series of wines (Table 1) indicate no major differences between the series. With both high and low sulfur dioxide levels at the three lowest temperatures (32°, 53°, and 70° F), total and free sulfur dioxide concentrations declined fairly rapidly during the first 9 months. No major changes were noted after that time. At 120° F, both total and free sulfur dioxide continued to decrease up to the last determination, at 22 months.

In the third series of wines, the total and free sulfur dioxide determinations (Table 2) reflect the same changes for the corked sample as described for the first 2 series. The capped samples, however, showed some interesting variations. For the high sulfur dioxide levels the temperature effect at 70° F is quite pronounced at 9 months for both the total and free sulfur dioxide concentrations. Also considerably greater losses in sulfur dioxide concentration are noted in the high level of sulfur dioxide in all the capped samples as compared with the corked ones at the same temperatures throughout the entire storage period. At the lower levels of sulfur dioxide, however, capped and corked samples showed only slight differences in sulfur dioxide concentrations.

Slight differences were noted between high and low sulfur dioxide concentrations in pH and in total acids, but no more than would be expected from the addition of a weak acid to a buffered solution. Temperature, time, and closure were not related to pH or total acid.

Color effects from the 2 levels of sulfur dioxide are pronounced. These data (Table 3) show that the high level of sulfur dioxide, at the 3 lower temperatures, kept the wine almost water white, whereas at the low

TABLE 2

Effects of sulfur dioxide at two concentration levels in wine from temperature, time, and closures (Series III)

Closure	Temperature of storage °F	Relative sulfur dioxide level	Total sulfur dioxide mg/l			Free sulfur dioxide mg/l		
			Time of storage (months)			Time of storage (months)		
			1	9	22	1	9	22
Cap (metal)	32	High	248	207	180	168	136	97
	53		232	191	112	153	110	17
	70		210	134	69	130	61	6
	120		188	16	8	102	2	1
	32	Low	41	27	22	12	7	3
	53		37	26	20	7	4	3
	70		36	25	21	7	2	2
	120		19	7	7	4	2	1
Cork	32	High	234	218	205	165	....	144
	53		227	188	197	149	122	112
	70		222	175	207	144	104	115
	120		198	118	....	108	43	....
	32	Low	41	29	24	15	4	3
	53		37	26	33	7	3	3
	70		36	23	22	7	3	3
	120		20	9	....	7	3	....

TABLE 3

Color of wines after twenty-two months storage with the various treatments (Series I, II, and III)

Series	Closure	High sulfur dioxide				Low sulfur dioxide			
		32° F	58° F	70° F	120° F	32° F	58° F	70° F	120° F
		Duboscq[1] color readings							
I	Cork	3.8	3.8	3.8	60.0	6.4	7.3	9.1	.....
II	Cork	3.8	3.8	3.8	19.4	6.1	6.2	6.1	26.0
III	Cork	3.6	3.6	3.6	.....	6.8	6.3	7.9	.....
III	Cap	3.6	4.0	4.8	52.0	7.7	7.9	8.3	25.0
		% Transmission[2] at 540 mmc							
I	Cork	97.1	97.0	97.2	63.8	94.4	94.2	94.0	.....
II	Cork	97.7	97.0	96.9	92.8	95.5	96.4	96.5	86.5
III	Cork	97.1	98.5	97.4	.....	93.9	95.9	94.1	.....
III	Cap	97.1	97.1	97.3	71.0	93.9	94.2	94.4	77.0

[1] Duboscq color comparator readings decrease as color decreases.
[2] Per cent transmission measured with 10 mm cell, water reference, in Beckman DU spectrophotometer.

level the color was close to what would be normal after 22 months. At 120° F at both high and low levels of sulfur dioxide the color became very dark. Some corked samples at 120° F were lost in storage, liquid expansion pushing out the corks. Of the remaining samples several had relatively high sulfur dioxide concentrations yet darkened in color. At the 120° F storage temperature the capped sample at the higher initial sulfur dioxide concentration became much darker than the sample at the lower sulfur dioxide level. It is also interesting that, at the end of the storage test, both were down to a very low value of free sulfur dioxide (1.0 mg per liter).

Tasting results (Tables 4 and 5) indicate a high degree of consistency between series I and II. In both cases, significant differences were found with differences in time, tasters, sulfur dioxide levels, and storage temperatures. The interactions indicate that the wine tasters did not all react the same to time of storage and to sulfur dioxide level. In the second series there was also a significant interaction between tasters and temperatures of storage.

Significant differences in the mean scores for the first 2 series (Tables 6 and 7) indicate that the 120° F storage temperature for one month (or less) was detrimental to the wines. The high sulfur dioxide level wines were generally scored significantly lower than the low sulfur dioxide level wines. The high level sulfur dioxide wines scored relatively lower as

TABLE 4

Analysis of variance[1] (Series I)

Source of variation	s.s.	d.f.	Var.
Total	1,369.36	143	
Time	59.82	2	29.91**[2]
Tasters	305.15	7	43.59**
Levels SO_2	350.00	1	350.00**
Temperatures	64.26	2	32.13**
Interactions			
Tasters × Time	144.93	14	10.35**
Temp × Time	23.86	4	5.96
SO_2 × Tasters	68.99	7	9.86**
SO_2 × Time	12.47	2	6.24
SO_2 × Temp	11.57	2	5.78
Temp × Tasters	71.82	14	5.13
Error	256.48	88	2.91
Combined error term	376.21	110	3.42

[1] The 120° F storage temperature not included in this analysis.
[2] ** Significant at 1% level.

time progressed than did the lower level sulfur dioxide wines. At the 3 lower storage temperatures at both sulfur dioxide levels there seem to have been no consistent significant mean-score differences between these storage temperatures, although the quality scores decreased in general as temperature increased. If the results for the two sulfur dioxide levels are combined, however, significant differences are found between quality scores for the 3 lowest tem-

TABLE 5

Analysis of variance[1] (Series II)

Source of variation	s.s.	d.f.	Var.
Total	1,689.46	143	
Time	43.19	2	21.60*[2]
Tasters	374.36	7	53.48**
Levels SO_2	368.96	1	368.96**
Temperatures	56.92	2	28.46**
Interactions			
Tasters × Time	170.62	14	12.19**
Temp × Time	7.12	4	1.78
SO_2 × Tasters	86.58	7	12.37*
SO_2 × Time	2.24	2	1.12
SO_2 × Temp	4.48	2	2.42
Temp × Tasters	143.55	14	10.25*
Error	431.08	88	4.90
Combined error term	445.28	96	4.64

[1] The 120° F storage temperature not included in this analysis.
[2] * Significant at 5% level. ** Significant at 1% level.

peratures. In series I mean scores for the 2 lowest temperatures are significantly better than that for 70° F, and in series II the mean score for 32° F is significantly better than those for the higher temperature. In both series, if the 120° F storage data are not included, except for the 9-month storage period in Series I, the over-all mean scores for 1-month storage are significantly better than those for the 9-month and 22-month storage periods. If the 120° F storage data are included, no significant differences are found between the 9-month and 22-month storage periods, and the 1-month storage is significantly better.

In series III, on the basis of the data available and partially because of the interaction of tasters with closures, differences are significant only for time and sulfur dioxide levels (Table 8). Some trends were weakly indicated between the two closure types, but the analysis showed no significant differences. Again,

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TABLE 6

Significant differences[1] in mean scores (Duncan multiple range test)
(Series I)

Storage time (months)	Low SO_2 level					High SO_2 level			
	Storage temperatures, ° F								
	32°	53°	70°	120°		32°	53°	70°	120°
1[2]	15.9	16.6	14.0	9.9	Sig Diff ⟷	12.5	13.9	12.6	11.0
9	15.9	15.5	14.6	5.5	Sig Diff ⟷	12.6	14.4	10.5	4.8
22	15.5	14.5	14.3		Sig Diff ⟷	11.1	11.0	10.1	6.4

Mean scores with temperature (Three lowest temperatures, ° F)			Mean scores with time Storage time (months)			
32°	53°	70°	1	9	22	
13.8	14.2	12.2	13.3	11.7	11.8	(includes 120° F storage)
			14.2	13.9	12.7	(excludes 120° F storage)

[1] Mean scores underscored by same line are not significantly different. Vertical lines pertain to scores left of the line (same meaning as horizontal lines). Arrows indicate significant differences between groups of means.
[2] Values underscored by the dotted lines are not significantly different.

TABLE 7

Significant differences[1] in mean scores (Duncan multiple range test)
(Series II)

Storage time (months)	Low SO_2 level					High SO_2 level			
	Storage temperatures, ° F								
	32°	53°	70°	120°		32°	53°	70°	120°
1	16.3	15.1	14.1	10.4	Sig Diff ⟷	12.6	11.6	12.6	10.3
9	15.6	13.9	13.1	4.9	Sig Diff ⟷	12.0	10.8	10.1	5.8
22	14.1	14.8	14.0	5.8	Sig Diff ⟷	12.2	10.2	9.9	

Storage temperature ° F	Storage time (months)						
	1	9	22		1	9	22
32	16.3	15.6	14.1	Sig Diff ⟷	12.6	12.0	12.2
53	15.1	13.9	14.8	Sig Diff ⟷	11.6	10.3	10.2
70	14.1	13.1	14.0	Sig Diff ⟷	12.6	10.1	9.9
120	10.4	4.9	5.8		10.3	5.8	

Mean scores with temperature (Three lowest temperatures, ° F)			Mean scores with time Storage time (months)			
32°	53°	70°	1	9	22	
13.8	12.7	12.3	12.9	10.8	11.6	(includes 120° F storage)
			13.7	12.6	12.5	(excludes 120° F storage)

[1] Mean scores underscored by the same line are not significantly different. Arrows indicate significant differences between groups of means.

at the low level of sulfur dioxide and for both cork and cap closures, the general trend was in favor of the two lowest storage temperatures. No such trends were evident at the high sulfur dioxide level, however. Because of this and because of the limited number of tastings and taster interactions, no significant temperature effect can be demonstrated statistically in this series.

The analyses of the rankings for quality are not included, but show essentially these same results for the 3 series.

SUMMARY

In wine stored with cork closures, at two sulfur dioxide levels and at temperatures of 32°, 53°, and 70° F the relative free and total sulfur dioxide changed only slightly in a 22-month period. In general, cork-closed wines at the lowest storage temperature received the best scores; specifically, the 32° F storage temperature resulted in a significantly better mean score than did the higher temperatures.

TABLE 8

Analysis of variance[1]
(Series III)

Source of variation	s.s	d.f.	Var.
Total	1,797.56	143	
Levels of SO_2	210.25	1	210.25**[2]
Closures	6.56	1	6.56
Time	168.44	2	84.22**
Temperature	37.10	2	18.55
Interactions			
Closures × SO_2	10.58	1	10.58
Closures × Temp.	10.32	2	10.32
Closures × Time	32.06	2	16.03
SO_2 × Time	0.29	2	0.15
SO_2 × Temp.	41.38	2	20.69
Temp × Time	34.77	4	8.69
Error	1,245.81	124	10.05

[1] The 120° F storage temperature not included in this analysis.
[2] ** Significant at 1% level.

Wine quality also varied with sulfur dioxide level. Wines stored at the lower sulfur dioxide level (100 mg per liter) were of significantly better quality than wines stored at the higher level (250 mg per liter). In general, wine quality deteriorated with time of storage.

Sulfur dioxide content at the higher levels declined more rapidly with metal closures than with cork closures. Higher temperature speeded the decline. Again, time of storage and sulfur dioxide levels caused significant differences in quality. In this experiment no significant effects on wine quality were found from closures or from the three lowest storage temperatures.

Storage at 120° F was very detrimental to wine quality in all cases.

CONCLUSIONS

For dry white table wines, this experiment indicates that:

1. Lower storage temperatures generally result in higher-quality wine.

2. Wine quality under these conditions usually deteriorates in bottles stored for periods exceeding 9 months, and in some cases for lesser periods.

3. The levels of sulfur dioxide used should be the lowest *practical*.

LITERATURE CITED

1. Amerine, M. A. *Laboratory Procedures for Enology.* 1955. Dept. of Viticulture and Enology. University of Calif. mimeo. 108 p.
2. Amerine, M. A. Composition of wines. II. Inorganic constituents. *Advances in Food Research*, **8**, 123–224 (1958).
3. Amerine, M. A., and Joslyn, M. A. *Table Wines: The Technology of Their Production in California.* 1951. University of Calif. Press, Berkeley.
4. Amerine, M. A., and Ough, C. S. (Unpublished data).
5. Amerine, M. A., Roessler, E. B., and Filipello, F. Modern sensory methods of evaluating wine. *Hilgardia*, **28**, 477–567 (1959).
6. Berg, H. W., Filipello, F., Hinreiner, E., and Webb, A. D. Evaluation of thresholds and minimum difference concentrations for various constituents of wines. I. Water solutions of pure substances. *Food Technol.*, **9**, 23–26 (1955).
7. Duncan, D. B. Multiple range and multiple F tests. *Biometrics*, **11**, 1–42 (1955).
8. Gentilini, L. L'anidride solforosa nei vini. *Rev. Viticolt. ed Enol.* (Conegliano), **2**, 243–244 (1949).
9. Ingram, M. The germicidal effects of free and combined sulfur dioxide. *J. Soc. Chem. Ind.*, **67**, 18–22 (1948).
10. Ingram, M. The antimicrobial action of sulfurous acid. *Rev. Ferm. Indus. et Aliment.*, **13**, 179–188 (1958).
11. Joslyn, M. A. How to cut down on SO_2 content. *Wines and Vines*, **35**, 31–34 (1954).
12. Joslyn, M. A., and Braverman, J. B. S. The chemistry and technology of the pretreatment and preservation of fruit and vegetable products with sulfur dioxide and sulfites. *Advances in Food Research*, **5**, 97–160 (1954).
13. Schelhorn, W. V. Untersuchungen über Konserviesungsmittelli. VII. *Deut. Lebensm. Rundschau*, **47**, 170–173 (1951).

Chemical and Physical Changes in Green Beans During Preparation and Processing*

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CHANGES OCCUR during the handling, blanching and retorting operations that affect the texture of canned green beans. These unit operations are so highly mechanized and controlled in modern processing plants that many factors that contribute to a change in texture may be unrecognized.

Texture variability of canned beans, a subject of much discussion throughout the bean industry of the United States, has largely been defined in terms of sloughing of the epidermis of the bean pods *(15)*.

Resistance to epidermal breakdown increases with the maturity of the pods *(15)*. However, the sloughing of immature pods is less objectionable due to the thin layer of sloughed skin. Post-harvest storage of fresh beans, long blanch periods at low temperatures and holding blanched beans in brine at elevated temperatures were recommended as means of reducing the tendency of the epidermal layer to slough.

Previous investigations have covered many phases of bean quality, yet there has been no attempt to relate chemical constituents of bean pods to texture of canned beans. Changes in chemical composition of fresh bean pods during maturation have been reported *(1, 2, 3, 9)* Differences in soluble solids, total solids and easily-hydrolyzable reserve polysaccharides between fresh and canned beans were found to be significant at all stages of maturity. Alcohol-insoluble-solids in canned beans were significantly lower than in fresh beans at the immature stage. Cellulose content remained the same in canned beans; otherwise, all other constituents leached into the liquor *(8)*. Total nitrogen and nitrogenous fractions of beans did not materially change during blanching *(17)*.

Blanching beans for 1.5 min at 212° F resulted in the same quality as 4.5 min at 185° F when the canned beans were evaluated for color, flavor and texture *(17)*. It has been demonstrated that there is a critical temperature range at which these quality factors are benefited by heating. This range for string beans is 180° to 195° F *(10)*. The most widely accepted commercial blanch for green beans for canning is 1.5 min at 180° F. Resistance to sloughing can be increased by increasing the time of blanch at 5 min *(15)*.

The role of pectinous materials in the firmness and consistency of many food products has been emphasized by numerous investigators. Pectin substances are of considerable importance in tomato paste consistency *(14)* and in clarification of citrus products *(5, 13)*. The enzyme, pectinmethylesterase, was found to be involved in gelation and clarification of orange juice *(5)*. Softening in cucumbers during fermentation was attributed to the action of polygalacturonase on pectic substances *(4, 7)*. The water-soluble pectin in cucumbers increased during spoilage (softening) by the conversion of insoluble pectic material (protopectin) to smaller molecules *(7)*. Firmer varieties of cucumbers remained firmer during the fermentation process than softer varieties. The general softening in cucumber stock was accompanied by a conversion of acid-soluble to versene-soluble pectic substances *(12)*.

Understanding some of the chemical changes that occur during preparation and processing of green beans should suggest improvements in processing techniques that would reduce the seriousness of sloughing. This paper relates the chemical constituents determined to the sloughing and firmness or softness of canned beans.

EXPERIMENTAL

Raw material. A large lot of sieve size 4 beans of Ferry Morse No. 1 strain (FM-1) of Blue Lake pole beans was used in the blanching experiments in 1957. Asgrow Regular (old Blue Lake) variety was compared with FM-1 as to differences in chemical composition in sieve sizes 1, 3 and 5 during the 1958 season.

Preparation and processing. Sieve size grading, snipping and cutting the beans into one-inch lengths were accomplished with commercial-size equipment. The cut beans were thoroughly mixed during random sampling of individual lots from the master sample. Blanching was conducted in a large stainless steel steam-kettle, which had a capacity of water to beans of approximately 50 to 1 during blanching. Beans were blanched in two small-sized baskets, water and beans being kept in motion by agitation. Blanching water was changed between each treatment but not for replications.

The blanching temperatures were 130°, 140°, 150°, 160°, 170°, 180°, 190° and 200° F for each of the times 1.5, 5 and 10 min and the combinations replicated two times. The treatments for the variety comparisons were "no blanch", 159° F, 184° F and 204° F, the time of blanch being 1.5 min with the combinations replicated 3 times.

After blanching and water cooling, the beans were packed in plain 303 x 406 cans to a constant fill-in weight of 9 oz. Boiling water was added prior to closing in an automatic steam-flow machine. No salt was added to the cans. Beans were processed for 20 min at 240° F, cooled in running water, and stored at room temperature until analyzed.

Analysis and evaluation of fresh and canned beans. Determinations made were dry matter, alcohol-insoluble-solids, pectin fractions (water-soluble, sodium hexametaphosphate-soluble, and alkali-soluble), starch, and both reducing and total sugars. In addition, resistance to shear and amount of sloughing were determined on the canned beans.

Resistance to shear was measured by the shear-press *(11)*. A sample of 150 g of drained, canned beans was carefully placed in the cup of the standard cell. Machine speed was set at 5½ with a gauge pressure of approximately 300 lb. Sloughing was determined by a mechanical device for which the details have been reported previously *(19)*.

All of the analytical determinations were made on ground samples which were prepared by blending 100 g of beans with an equal weight of water to obtain a uniform slurry. Liquid was drained from the canned beans prior to sampling, and the liquor analyzed separately.

* Technical Paper No. 1296, Oregon Agricultural Experiment Station. Contribution of the Department of Food and Dairy Technology, Oregon State College, Corvallis, Oregon.

TABLE 1

Effect of temperature and time of blanch on alcohol-insoluble-solids of canned beans (dry weight basis) Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch								Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	g/100 g (per cent)								
1.5	60.89	64.17	56.48	57.66	55.94	56.68	61.07	60.43	59.16
5	61.97	63.13	58.25	58.88	57.08	54.18	59.26	59.99	59.09
10	60.76	61.17	61.86	57.16	52.00	59.02	60.33	60.69	59.12
Temperatures of blanch mean	61.21	62.80	58.86	57.90	55.00	56.62	60.22	60.37	

Effect of temperatures—HSD: LSD (.01) 4.59. Interaction—HSD. Effect of times—NSD.

TABLE 2

Effect of temperature and time of blanch on reducing sugar content of canned beans (dry weight basis) Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch								Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	g/100 g (per cent)								
1.5	32.49	34.44	25.23	25.05	26.14	29.09	28.64	27.75	28.60
5	32.04	37.26	24.73	25.30	27.29	26.48	26.19	27.51	28.35
10	31.16	31.31	25.18	24.52	27.42	27.30	26.19	26.76	27.48
Temperatures of blanch mean	31.89	34.33	25.05	24.95	26.95	27.62	27.01	27.34	

Effect of temperatures—HSD: LSD (.01) 3.09. Interaction—HSD. Effect of times—NSD.

Dry matter was determined on duplicate 20 g samples by weighing into tared aluminum cups and drying for 24 hours at 70° C and 25 inches of vacuum.

Sugar analyses were run by the alkaline ferricyanide method *(16)*. Starch was estimated from the washed, wet residue remaining after the sugar analyses by direct acid hydrolysis and calculating starch from the reducing fraction.

Alcohol-insoluble-solids (AIS) was found by extracting 10 g samples of the original slurry in tared centrifuge tubes with 70% ethyl alcohol. Three successive extractions were made by heating for 10 min at 80° C in a water bath followed by 10 min of centrifugation at 500 x gravity. The remaining residue was dried and weighed. Accuracy of this method was comparable to the standard AOAC method.

Pectin fractions were estimated by the colorimetric carbazole method of Dietz and Rouse *(6)* with minor modifications. The tubes were kept in a cold water bath after the addition of sulfuric acid until the color was developed in the samples by heating for 10 min in a water bath at 80° C. Tubes were again returned to the cold water bath for cooling before readings were taken.

Conventional methods of analysis of variance were used on the data. Least significant differences (LSD's) were calculated on the temperature, time, treatment and size means. Significant differences (SD) refer to the 5% level of significance and highly significant differences (HSD) refer to the 1% level of significeance as computed by the analysis of variance. The main effects that were not significantly different (NSD) are indicated at the bottom of the tables.

RESULTS AND DISCUSSION

Blanched beans were analyzed immediately after blanching and canned beans after two months of storage. Results from both blanched fresh beans and canned beans will be discussed as to the changes in each chemical component. The discussion will include the possible relationship of each component to texture changes of canned beans. Sufficient data from canned beans only will be used to show important changes.

Effect of temperature and time of blanch on AIS and carbohydrates. The principal effect of different temperatures and times of blanch on alcohol-insoluble-solids (AIS) of blanched and canned beans (sieve size 4) was lower values in the 150° to 180° F range of blanching temperatures. Starch probably was the main component involved in these differences.

Maximum firmness of canned beans occurred in this range of temperatures although the AIS was not significantly correlated with texture. Significantly lower values for AIS occurred in beans blanched at 170° and 180° F as compared to the AIS means for temperature at 130° and 140° F (Table 1). The mean at 170° F was significantly lower than the means for blanch temperatures of 190° and 200° F.

Blanched fresh beans showed an increase in leaching of reducing sugars as temperature and time of blanch were increased. However, this effect was more pronounced in canned beans, as shown in Table 2, resulting in a greater difference in the content of reducing sugars between the low and the high blanching temperatures. Beans that were blanched at 130° and 140° F contained significantly more reducing sugars than those at the other temperatures. The lowest reducing sugar content in canned beans was obtained at 160° F, the temperature that exhibited the lowest percentage of sloughed skins in canned beans. Since a simple molecule like sugar moves freely across the cell membrane, it probably is not related directly to structural differences.

Effects of blanching temperatures and times on total sugars were similar to those shown for reducing sugars. There was an increased leaching of total sugars in blanched fresh beans as the time was increased at all temperatures. In canned beans, the effect of temperatures was highly significant but time did not significantly influence total sugars due to the interaction.

Starch content of blanched fresh beans was significantly affected by temperature and time of blanch. Similar values were obtained after canning. Enzyme-degradation of starch probably takes place between the temperatures of 130°–160° F as this was the range at which significantly lower starch contents were ob-

TABLE 3

Effect of temperature and time of blanch on starch content of canned beans (dry weight basis)
Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch							Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	g/100 g (per cent)								
1.5	18.11	17.67	16.66	19.42	21.56	22.88	21.97	21.00	19.91
5	17.16	18.03	18.70	17.92	22.45	23.60	23.07	23.66	20.57
10	16.59	17.68	19.78	17.11	21.99	23.39	23.57	22.62	20.34
Temperatures of blanch mean	17.28	17.79	18.38	18.15	22.00	23.29	22.87	22.42	

Effect of temperatures—HSD: LSD (.01) 2.32. Interaction—HSD. Effect of times—NSD.

TABLE 4

The effect of temperature and time of blanch on water-soluble pectin of canned beans (dry weight basis)
Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch							Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	g/100 g (per cent)								
1.5	3.576	3.301	2.293	2.439	3.624	4.114	5.044	5.460	3.731
5	3.784	3.832	2.259	2.455	3.547	4.128	4.168	3.986	3.520
10	3.344	3.492	2.270	2.366	3.475	3.894	3.926	3.593	3.295
Temperatures of blanch mean	3.568	3.541	2.274	2.420	3.549	4.045	4.379	4.346	

Effect of temperatures—HSD: LSD (.01) 0.955. Interaction—HSD. Effect of times—NSD.

served (Table 3). Starch content was lowest in canned beans that were treated at 130° F for 10 minutes.

High starch content in many vegetables is directly related to firmer texture of the processed product, but there do not appear to be any trends in these data to indicate such a relationship in pole snap beans. Starch content was highest in canned beans when blanched at temperatures of 180–200° F.

Pectin fractions as affected by temperature and time of blanch, variety, and size of beans. Blanched fresh beans showed an increase in water-soluble pectin as the time and temperature of blanch were increased. The lowest water-soluble pectin content was observed at the 130° F blanching temperature for a time of 1½ min and the highest was recorded at 200° F for 10 min.

The parent pectin (protopectin), which appeared largely in the alkali-soluble fraction in blanched fresh beans, was hydrolyzed during the retorting process to more soluble pectins. Water-soluble pectin increased to a high level after canning (Table 4). The temperature of blanch prior to canning significantly influenced this component. The increase in time of blanch beyond 1.5 minutes at temperatures above 180° F markedly decreased the water-soluble pectin.

In most instances, the water-soluble pectins in canned beans of Asgrow Regular variety were higher than those of FM-1 variety (Tables 5a and 5b). When blanched at temperatures of 159° and 184° F, water-soluble pectin contents in canned beans of FM-1 variety were lowest; whereas, the 204° F blanch treatment resulted in the highest value. Only Asgrow Regular variety showed significant differences as a result of blanching treatments.

Effects of sizes of beans on water-soluble pectin content in canned beans were significant in both varieties, the size 5 beans giving the higher values (Tables 5a and 5b).

TABLE 5

Effect of variety, size of beans and treatment on water-soluble pectin of canned beans (dry weight basis)

a. Variety—FM–1—Means of individual treatments

Sizes	Treatments				Means for sizes
	No blanch	159°	184°	204°	
	g/100 g (per cent)				
1	2.239	2.276	2.311	2.763	2.397
3	3.015	2.043	2.670	2.630	2.590
5	3.025	2.682	3.314	3.434	3.114
Means for treatments	2.760	2.334	2.765	2.943	

Effect of treatments—NSD. Interaction—HSD. Effect of sizes—SD: LSD (.05) 0.449.

b. Variety—Asgrow Regular—Means of individual treatments

Sizes	Treatments				Means for sizes
	No blanch	159°	184°	204°	
	g/100 g (per cent)				
1	2.591	2.336	2.526	2.740	2.548
3	2.992	2.721	2.986	3.127	2.956
5	3.314	3.026	3.119	3.553	3.253
Means for treatments	2.966	2.694	2.877	3.140	

Effect of treatments—HSD: LSD (.01) 0.193. Interaction—HSD. Effect of sizes—HSD: LSD (.01) 0.167.

Water-soluble pectin in the liquid from canned beans provided a better index of sloughing than data from drained canned beans ($r = +0.878$).

The main effect of different temperatures of blanch on pectate-pectinates in blanched fresh beans was an increase in this fraction at 190° and 200° F. This represents a shift in alkali-soluble pectin to more soluble forms since the alkali-soluble fraction decreased at these temperatures. Pectate-pectinates decreased in the 130° to 160° F range of blanching temperatures as the time of blanch was increased.

Maximum values for pectate-pectinates in canned beans resulted from blanching at 160° F (Table 6). Both temperature and time of blanch significantly

TABLE 6

Effect of temperature and time of blanch on pectate-pectinates of canned beans (dry weight basis)
Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch								Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	g/100 g (per cent)								
1.5	3.252	3.162	3.231	3.472	3.512	3.009	2.245	1.751	2.954
5	3.248	3.608	3.731	4.201	3.831	3.156	2.408	1.932	3.264
10	3.482	3.866	4.167	4.287	4.116	3.472	2.601	2.137	3.516
Temperatures of blanch mean	3.327	3.545	3.710	3.987	3.820	3.212	2.418	1.940	

Effect of temperatures—HSD: LSD (.01) 0.247. Interaction—NSD. Effect of times—HSD: LSD (.01) 0.151.

affected pectate-pectinates, the effect of temperature being significant in both varieties. Furthermore, both varieties of beans, Asgrow Regular and FM-1, showed maximum firmness in canned beans when blanched at 160° F. Effect of pod sizes on pectate-pectinates was not significant in either of the varieties studied.

There was a highly significant negative correlation between per cent pectate-pectinates in canned beans and per cent sloughed skins ($r = -0.888$). Also, resistance to shear showed a significant positive correlation with pectate-pectinates (+0.908). Robinson, Stotz and Kertesz *(18)* obtained higher calcium contents in canned beans that received a longer blanch at lower temperatures as compared to a short blanch at high temperatures. Softening of canned beans when blanched at high temperatures (180°–200° F) may be synonymous with the condition they described as "thermal maceration" in vegetables.

Alkali-soluble pectin increased in fresh beans with an increase in diameter of the pods although it increased less in Asgrow Regular than in the FM-1 variety. During blanching at low temperatures, there was an increase in alkali-soluble pectin.

Since alkali-soluble pectin (protopectin) is hydrolyzed during canning to more soluble pectins, temperature and time of blanch markedly affected this fraction in canned beans. It increased with time of blanch in the 150°–170° F range of blanching temperatures. Very little parent protopectin remains in canned beans as compared to fresh beans.

The effect of size of beans on alkali-soluble pectin in canned beans of FM-1 variety was not significant due to the highly significant interaction (Table 7a). In Asgrow Regular variety, alkali-soluble pectin of canned beans decreased with an increase in size in all treatments except at 204° F (Table 7b).

Correlations of alkali-soluble pectin with sloughed skins and resistance to shear were similar to those of the pectate-pectinates fraction, (r's $=$ -0.832 and $+0.886$, respectively). The highest percentages of alkali-soluble pectin were found at the same range of blanching temperatures at which percentages of pectate-pectinates were highest.

TABLE 7

Effect of variety, size of beans and treatment on the alkali-soluble pectin of canned beans (dry weight basis)

a. Variety—FM–1—Means of individual treatments

Sizes	Treatments				Means for sizes
	No blanch	159°	184°	204°	
	g/100 g (per cent)				
1	0.489	0.520	0.386	0.338	0.433
3	0.417	0.537	0.444	0.309	0.425
5	0.420	0.601	0.530	0.482	0.508
Means for treatments	0.442	0.553	0.453	0.373	

Effect of treatments—SD: LSD (.05) 0.112. Interaction—HSD. Effect of sizes—NSD.

b. Variety—Asgrow Regular—Means of individual treatments

Sizes	Treatments				Means for sizes
	No blanch	159°	184°	204°	
	g/100 g (per cent)				
1	0.554	0.661	0.555	0.405	0.544
3	0.475	0.634	0.489	0.384	0.496
5	0.438	0.510	0.468	0.386	0.451
Means for treatments	0.489	0.602	0.504	0.392	

Effect of treatments—HSD: LSD (.01) 0.103. Interaction—HSD. Effect of sizes—SD: LSD (.05) 0.059.

Percentage of sloughed skins of canned beans was not significantly affected by time of blanch due to the highly significant interaction. Although effect of time was not significant, there was a definite influence of time at most of the temperatures (Table 8). Despite the highly significant interaction, temperature of blanch significantly affected the per cent of sloughed skins in canned beans. Percentage of sloughed skins was significantly lower in canned beans that were blanched at temperatures between 150°–170° F inclusive, as compared to those blanched at 180°, 190° and 200° F. It can be seen in Table 8 that an increase

TABLE 8

Effect of temperature and time of blanch on per cent sloughed skins of canned beans
Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch								Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	Dry residue, g/100 g drained beans								
1.5	.2085	.1891	.1249	.0644	.0802	.1881	.3682	.5424	.2207
5	.3096	.1991	.0982	.0304	.0259	.1606	.3351	.4944	.2066
10	.3205	.1463	.0909	.0335	.0439	.2573	.4560	.5479	.2370
Temperatures of blanch mean	.2795	.1782	.1046	.0427	.0500	.2020	.3864	.5282	

Effect of temperatures—HSD: LSD (.01) .0983. Interaction—HSD. Effect of times—NSD.

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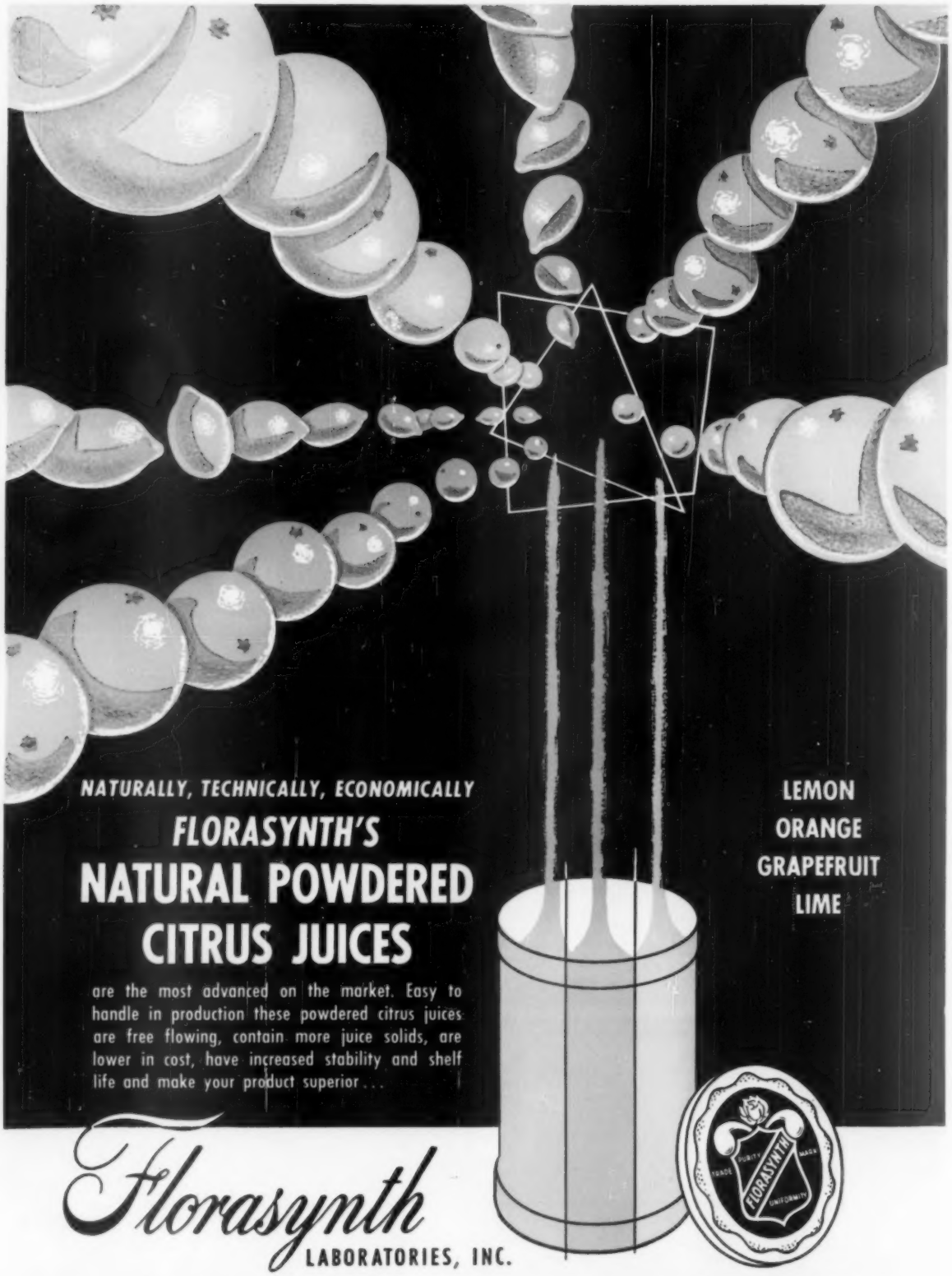
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in per cent of sloughed skins resulted when the temperatures of blanch were increased or decreased from this point in the range of blanching temperatures. The highest percentages of pectate-pectinates of canned beans corespond to the lowest percentages of sloughed skins (Tables 6 and 8).

The FM-1 strain of beans sloughed more than the Asgrow Regular variety in sieve sizes 1 and 3 in the treatments "no blanch", 159° F, and 184° F, but at 204° F Asgrow Regular exhibited a greater percentage of sloughing. The latter was true of all treatments in sieve size 5 beans, indicating that large sieve sizes of Asgrow Regular are more sensitive to high temperatures of blanch than the FM-1 strain (data not shown).

Resistance to shear was definitely affected by temperature and time of blanch (Table 9). The mean for time of blanch at 10 min was significantly higher than the means of either 1.5 or 5 min of blanch. Significantly softer canned beans were obtained when blanched at 190° and 200° F as compared to the other temperatures of blanch. Size of beans also affected the firmness of canned beans. The FM-1 strain showed a greater resistance to shear than Asgrow Regular in the sieve size 5 beans after canning (data not shown).

In preparing a recommendation for the processors to follow in order to prevent sloughing of the epidermis of pole snap beans the resistance to shear of canned beans should be noted (Table 9). In the sieve size 4 beans of FM-1 strain the 180° F blanch, which is the most commonly accepted commercial blanch for canned beans, produced significantly softer canned beans than the 170° F blanch. Furthermore, percentages of sloughed skins (Table 8) were significantly higher at the 180° F blanch. These data provide a good estimate of breakdown in texture as well as the epidermal cells of the bean pod since percentage of sloughed skins was highly significantly negatively correlated with resistance to shear. The high shear-press readings and low percentages of sloughed skins did not indicate the most ideal texture of canned beans because the canned beans were squeaky and too firm. Hay-like flavors occurred in beans that were blanched at temperatures below 170° F. Therefore, the optimum range of temperature for blanching pole snap beans in order to obtain the highest quality was found to be between 170° and 180° F.

Changes in the pectic substances appear to be closely related to the increase in sloughing of the epidermis and decrease in resistance to shear of canned beans as a significant increase in the water-soluble pectin and a significant decrease in the pectate-pectinates occurred between 170° and 180° F. Consequently, any specific recommendations for optimum blanching of pole snap beans prior to canning would be governed by the results of these determinations. In addition, optimum blanching would be conditioned by variety and size as indicated by the data presented.

SUMMARY AND CONCLUSIONS

A study was made of the effects of size and variety of beans and the temperature and time of blanch on the chemical constituents in blanched and canned beans. These constituents were related to texture in the canned beans. Texture was measured by per cent of sloughed skins and resistance to shear.

AIS was not correlated with either firmness or sloughing af canned beans. Total and reducing sugars of canned beans reached a minimum when beans were blanched at 150° to 170° F, the temperature range at which the texture was firmest and the percentage of sloughed skins was lowest, yet this relationship was not established at other blanching temperatures. Low starch content was found in this range of blanching temperatures, and high starch values in the range of 180° to 200° F.

Most of the texture changes in canned beans appeared to be related to changes in pectic substances during blanching and canning. Resistance to shear increased with an increase in per cent of pectate-pectinates, a highly significant positive correlation that existed in both phases of the experiment. Conversely, percentage of sloughed skins in canned beans was highly significantly negatively correlated with percentage of pectate-pectinates and alkali-soluble pectins.

In most instances, the resistance to shear of canned beans of individual treatments was greater in the FM-1 strain than Asgrow Regular variety. Furthermore, the skins of the sieve size 5 canned beans of Asgrow Regular sloughed more than FM-1, but the reverse was true in sieve size 1 beans.

It was concluded that blanching at temperatures between 170° and 180° F for a time of 1.5 to 5 min was optimum for pole snap beans. Since the percentages of sloughed skins and resistance to shear of canned beans were affected by temperature of blanch, time of blanch, size of beans, and variety the optimum blanch was conditioned by these factors. Closer control over the raw material was apparent in order to prevent squeakiness and off-flavors in beans that were under-blanched as well as softness and sloughing in

TABLE 9

Effect of temperature and time of blanch on resistance to shear of canned beans (kg pressure)
Means of individual treatments

Time of blanch (minutes)	Temperatures of blanch								Time of blanch mean
	130°	140°	150°	160°	170°	180°	190°	200°	
	kgs pressure								
1.5	24.4	28.7	32.6	31.0	29.3	24.6	20.5	19.2	26.3
5	24.1	31.0	32.7	33.4	30.9	24.9	20.1	19.1	27.0
10	31.9	38.7	36.4	36.5	35.2	26.3	21.7	19.4	30.7
Temperatures of blanch mean	26.8	32.8	33.9	33.6	31.8	25.3	20.8	19.2	

Effect of temperatures—HSD: LSD (.01), 4.5. Interaction—HSD. Effect of times—HSD: LSD (.01) 2.8.

beans that were over-blanched. Adjustments in the temperature of blanch or the time of blanch within this temperature range should be sufficient for controlling the sloughing and softening in pole snap beans for canning.

LITERATURE CITED

1. Bennett, Emmett. Ratio of soluble sugars, pectic materials, and hemicelluloses to nitrogen-free extracts of some common vegetables. *Food Research*, **9**, 462–464 (1944).
2. Buston, Harold William. Observations on the nature, distribution and development of certain cell-wall constituents of plants. *Biochem. J.*, **29**, 196–218 (1935).
3. Culpepper, C. W. Effect of stage of maturity of the snap bean on its composition and use as a food product. *Food Research*, **1**, 357–376 (1936).
4. Demain, Arnold L., and Phaff, Herman J. Cucumber curing: softening of cucumbers during curing. *J. Agr. Food Chem.*, **5**, 60–64 (1957).
5. Dietz, James Hadley. Relationship of pectic substance to clarification and gelation of concentrated citric juices. (Ph.D. thesis, University of Mass., Amherst, Mass., 1953).
6. Dietz, James H., and Rouse, A. H. A rapid method of estimating pectic substances in citrus juices. *Food Research*, **18**, 169–177 (1953).
7. Fabian, F. W., and Johnson, E. A. Experimental work on cucumber fermentation. Parts IX, X, XI, and XII. Mich. Agr. Expt. Sta. *Tech. Bull. 157* (1938).
8. Gould, Wilbur A. Quality evaluation of fresh, frozen and canned snap beans. Ohio Agr. Expt. Sta. *Bull. 701* (1951).
9. Janes, Byron E. The effect of varying amounts of irrigation on the composition of two varieties of snap beans. *Proc. Am. Soc. Hort. Sci.*, **51**, 457–462 (1948).
10. Joslyn, M. A., and Marsh, G. L. The role of peroxidase in the deterioration of frozen fruits and vegetables. *Science*, **78**, 174–175 (1933).
11. Kramer, A., Burkhardt, G. J., and Rogers, H. P. Jr. The shearpress, an instrument for measuring quality of food. *Canner*, **112** (3) 34–36 (1951).
12. Lampi, R. A., Esselen, R. B., Thomson, C. L., and Anderson, E. E. Changes in pectic substances of four varieties of pickling cucumbers during fermentation and softening. *Food Research*, **23**, 351–363 (1958).
13. Lineweaver, Hans, and Jansen, Eugene F. Pectic enzymes. *Advances in Enzymology*, **11**, 267–295 (1951).
14. McColloch, R. J., Nielson, B. W., and Beavens, E. A. Factors influencing the quality of tomato paste. II. Pectic changes during processing. *Food Technol.*, **4**, 339–343 (1950).
15. McConnell, John E. W. Factors affecting the skin of processed green beans. Confidential Research Report 205–56, National Canners Association, San Francisco, California (1956).
16. Morell, S. A. Rapid determination of reducing sugars. *Ind. Eng. Chem., Anal. Ed.*, **13**, 249–251 (1941).
17. Moyer, J. C., Robinson, W. B., Stotz, E. H., and Kertesz, Z. I. Effect of blanching and subsequent holding on some chemical constituents and enzyme activities in peas, snap beans and lima beans. N. Y. Agr. Expt. Sta. *Bull. 754* (1952).
18. Robinson, W. B., Moyer, J. C., and Kertesz, Z. I. "Thermal maceration" of plant tissue. *Plant Physiology*, **24**, 317–319 (1949).
19. Sistrunk, William Allen. Effect of certain field and processing factors on the texture of Blue Lake green beans (Ph.D. thesis. Oregon State College, Corvallis, Oregon, 1959).

Low Temperature Handling of Sterilized Foods

I. Design of Equipment and Outline of Processes Used

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(Manuscript received May 21, 1959)

HIGH TEMPERATURE short-time sterilization (HTST) may be defined as a process whereby foods are sterilized by heat applied for time periods ranging from a few seconds to a few minutes. In low-acid foods, process temperatures exceed 260° F. In our laboratory, all processing to date has been at 300° F.

The advantage of using an HTST processing technique lies in the fact that higher temperatures have less influence on quality impairment in proportion to their lethal effect on bacterial spores than lower temperatures have.

In order to process foods at high temperatures for such relatively short times, processing equipment that is workable in the high-temperature range, and that gives very fast heat penetration and allows accurate control of the process time and temperature, are required. Numerous papers (1, 2, 4, 5, 6, and 7) and patents dealing with this problem have been published.

In our project it was necessary to have equipment which would enable us to pack food of any type of physical form. This paper describes such equipment and indicates its use.

EXPERIMENTAL

Processing and equipment. The equipment used to date for high-temperature, short-time processing is shown in Figures 1 and 2. It consists of a retort of 30 in inside diameter, to which is attached a cylindrical chamber of 8 in inside diameter, called Chamber M, shown immediately to the left of the small cylindrical basket (upper right, Figure 1). Forty-four sealed cans (211 x 011) of food (2⅝ inches in diameter and ⅔ in high) are put into the basket. With the 8-in gate valve at the base of Chamber M closed, the retort is brought to the proper temperature for the process under study where it will be kept for the duration of the processing operation. The basket of cans is then sealed into Chamber M, the 8 in gate valve is rapidly opened, and the basket is lowered into the retort. When processing time has almost expired, the basket is elevated back into Chamber M. At the end of the processing time, the gate valve is closed and cold water is immediately sprayed onto the cans.

[a] Now with Ducher Packing Co., Dayton, Ohio.

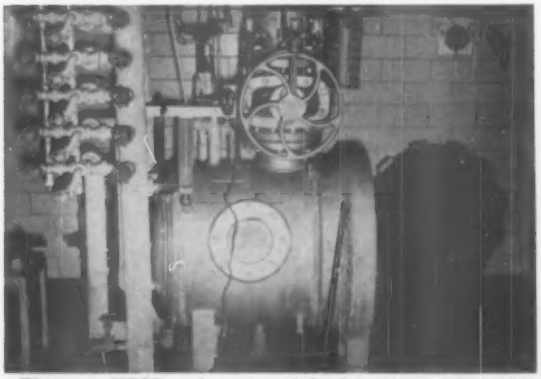

Figure 1. HTST equipment used for laboratory scale production. Chamber M and retort.

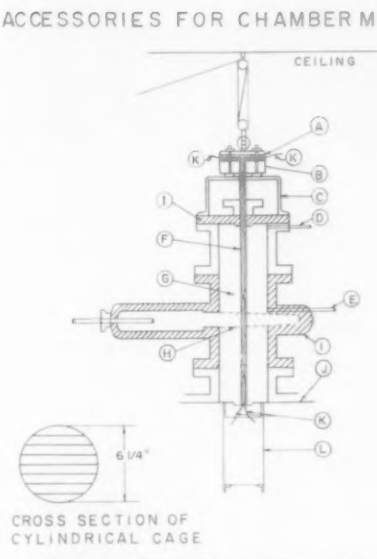

Figure 2. Cross-section elevation of chamber M.

A, packing; B, 30 lb weight; C, girdle holding weight and packing; D, ¾ in pipe connection, water, steam, air, or vacuum; E, *Ibid;* F, ¾ in stainless tube; G, Chamber M; H, 8 inch gate valve; I, wall of Chamber M; J, retort wall; K, "thermocouples"; L, cyclindrical cage for cans; M, block and tackle for raising and lowering the basket L. Gate value H shown in open position. Basket L shown in position for processing.

New HTST process and equipment. We are now putting into use new equipment by which the process will be further shortened and by which any HTST processing procedure in which the food is either partially or fully sterilized before sealing in the container can be carried out. However, a machine so versatile in operating technique must, to avoid great mechanical complexity, have some important limitations. It can handle only one type of container (the 211 x 300 can), and it has very limited operating speed—perhaps 1 can per minute.

It is shown without accessories in Figure 3; major operating parts are indicated in Figure 4.

Two methods of sterilization are possible: the food may be processed by direct steam treatment either prior to filling, or in the open-top can after filling. When processing prior to filling the empty can is placed in compartment I (Figure 4) through opening 1 while gate valve G_1 is closed. Port 1 is sealed shut, gate valve G_1 is opened, and the can is passed along the can track into compartment II by means of push rod P_1. The empty can is then placed at position 2 or 4 directly under heat exchanger A or A′ by movement of the can along the can track in compartment II by means of push rod P_2. The food to be sterilized is passed into heat exchanger A or A′. Each of these heat exchangers contains a stainless steel can so held that it can be turned through 360 degrees. The can is first in an upright position in order to receive the food to be sterilized.

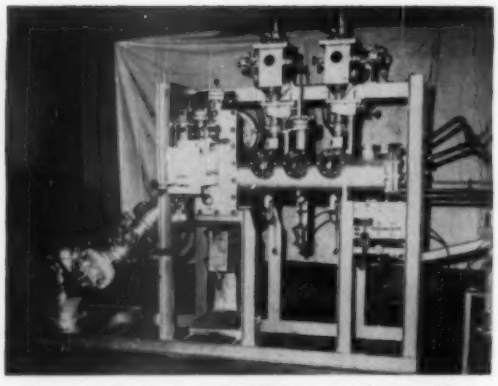

Figure 3. Semi-automatic HTST processing machine.

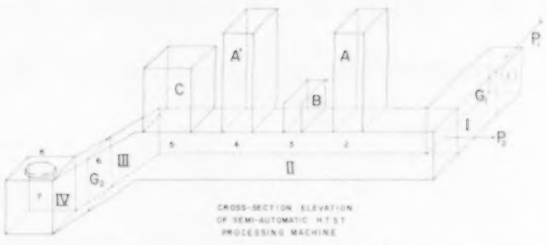

Figure 4. Cross-section elevation of semi-automatic HTST processing machine.

P_1, Push-rod; 1, Pressure tight door; G_1, Quick opening gate valve; I, Can entrance chamber; P_2, Push-rod; II, Main sterilizing and sealing chamber; A, Discrete particle heat exchanger; B, Sterilizing chamber for open can sterilization; A', Discrete particle heat exchanger; 2, Filling position; 3, Can holding position for open can sterilization; 4, Filling position; 5, Sealing position; C, Can sealer and lid sterilizer; III, Holding leg; 6, Holding position; G_2, Quick opening gate valve; IV, Cooling leg; 7, Position for can cooling; 8, Pressure tight door.

After filling, the entrance to the heat exchanger is closed, the can is turned about 45 degrees, a steam tube is then inserted into the food, and sterilization is performed by direct steam injection while the stainless steel container is agitated by being vibrated about its fulcrum. At the completion of the steam treatment, the steam tube is withdrawn, the container is turned another 135 degrees, the exit to the heat exchanger is opened, and the food falls by gravity through a stainless steel chute leading, if heat exchanger A is used, to the can at position 2, or, if heat exchanger A' is used, to position 4. Sterilization of the can will be effected either by residual heat in the food when it passes into the can, or by steam from a tube inserted into the can at station 3, or by maintaining steam pressure in compartment II.

The filled can is moved to position 5 where a previously sterilized lid is passed onto the can from the lid sterilizer; the can is then sealed by closing Machine C. The sealed can is next moved into compartment III, where it rolls through a twist chute. It can be held, if desired, at position 6 in order to allow residual heat to complete sterilization. Gate valve G_2 is opened and the can rolls into compartment IV which contains running cold water. After gate valve G_2 is closed and pressure in compartment IV is released, the can, when cooled, is removed from compartment IV through opening 8.

If sterilization is accomplished in a filled can the general procedure is as follows. The can is filled with the pre-heated product (180–200° F), placed into compartment I, and passed into compartment II to position 3 as described previously for the empty can. Position 3 is a platform which is moved up or down by air pressure. The platform is moved upward and can is positioned against the bottom of a cylinder extending downward within larger cylinder B. A steam tube located in B is lowered into the can to a position just short of the bottom of the can. The steam is turned on and the small cylinder at B is allowed to come to the predetermined working temperature for sterilization. This cylinder is approximately 3 times the height of the can in order to allow the food to percolate during sterilization. At the end of the sterilization period, the tube is retracted and the steam is turned off. The chamber is vented to allow flash cooling and the flashing off of any moisture added to the product. Platform 3 is lowered and the can passed on to the sealing, holding, and cooling positions as described previously.

It can be seen that a good deal of flexibility is allowed by either type of processing. Both cases cited embody idealized conditions, and changes in operating techniques would depend upon the nature of the product being handled.

Depending upon the technique of processing being followed, the pressure maintained in the machine will vary from approximately 2 lb to perhaps 60 or 70 psi. The pressure may be maintained by steam, by air, by inert gas, or by a combination of these, depending upon (1) the relationship required between pressure and temperature, 2) whether or not the operations within the machine are conducted aseptically, (3) the temperature of the food when it is filled into the can, and (4) whether or not oxygen must be excluded from contact with the food in the machine. It is possible to maintain stratified con-

TABLE 1

Process temperatures and times of products packed

Product	HTST process * Process time		Conventional process		
	Min	Sec	Can size	Retort temp	Process time
				° F	*Min*
Tomato juice	1		307 x 409	212	25
Cut green beans		50	211 x 300	245	15
Cream style corn	1	55	307 x 409	245	75
Asparagus		50	211 x 300	240	23
Evaporated milk	1	15	300 x 306,5	1)242 2)242	1)20 2)16
Oyster stew soup	1	40	211 x 400	245	20
Green pea with ham soup	1	45	211 x 400	245	53
Vegetable beef soup	1	50	211 x 400	245	53
Cream of shrimp soup	2		211 x 400	245	53
Cream of potato soup	3		211 x 400	245	53
Whole kernel corn	1	20	307 x 409	245	40
Green peas	1		211 x 400	250	15

* For this process, can size for all products was 211 x 011; and retort temperature = 300° F.

[1] Cans were rotated end over end at a speed of 12 rpm. Come-up time was 15 min, to reach retort temperature of 242° F, holding time at 242° F, 15 min.

[2] Processed in an Anderson-Barngrover continuous cooker. Come-up time was 20 min, to temperature of 208° F, in the milk, followed by a holding time of 16 min, at a retort temperature of 242° F.

[3] The process times used for the HTST products were calculated from the heat penetration and lethality data gathered on each product. The conventional process times and temperatures were either taken from National Canners Association Bulletin 26L or were those currently being used by the processor.

ditions within the machine; for example, to maintain aseptic conditions with steam over the tops of the cans along their path of travel from the filling station, or from the sterilizing station to the sealing station, while other regions within the enclosure are neither sterile nor at a lethal temperature.

RESULTS AND DISCUSSION

Table 1 lists the products packed thus far, using the technique described for operating Chamber M. The list shows a large difference in process times even among the HTST processes because heat penetration is a substantial factor even in the relatively shallow 211 x 011 can.

The heat penetration curve of a slowly heating (conduction heating) product, such as green pea with ham soup in a 211 x 011 can at a retort temperature of 300° F, has an f (slope index) value of 2.1 min. The corresponding f value for the same product in a 211 x 400 can at a retort temperature of 245° F was found to be 36.0 min. The f value for a relatively rapid-heating product (convection heating), such as green peas in brine, was found to be 0.80 to 1.0 min in the 211 x 011 can at a retort temperature of 300° F, and approximately 10.0 min in a 307 x 409 can at a retort temperature of 245° F.

More rapid heat penetration than that of the 211 x 011 can is expected to be obtained in the direct steam injection procedures described for the new HTST processing machine detailed at the beginning of this paper. By employing this new machine in our future work, we hope to demonstrate the practicability of the HTST process to containers of any size.

SUMMARY

Two systems for the high-temperature, short-time sterilization of low acid products have been discussed. The first system is a batch operation for the production of laboratory-size quantities of HTST sterilized products. The second system simulates a continuous procedure and is capable of processing material by several different methods which are feasible for commercial application. Both systems are capable of handling liquid, semi-liquid, and discrete particle products.

Acknowledgment

The authors wish to acknowledge the contribution of Mr. G. J. Lauro of this department to the data reported in this paper.

The authors also wish to acknowledge support of this project by the following companies and government agencies: United States Public Health Service; Eastern Utilization Laboratory, U.S.D.A., Philadelphia, Pa.; Refrigeration Research Foundation; Washington Laboratory, National Canners Association; Food Laboratory, Whirlpool Corp., St. Joseph, Michigan; American Can Company; Campbell Soup Company; Borden Food Company; H. L. Smith, Jr., Inc.

LITERATURE CITED

1. Anonymous. New "flash-heating" process announced at conference. *Canner*, 106 (5) 18 (1948).
2. Clifcorn, L. E., Peterson, G. F., Boyd, J. M., and O'Neil. A new principal for agitating in processing of canned foods. *Food Technol.*, 4, 450 (1950).
3. Ball, C. O., and Olson, F. C. W. *Sterilization in Food Technology*. 1st ed. 1957. McGraw-Hill Book Co., Inc., New York.
4. Conley, W., Kaap, L., and Schuhmann, L. The application of "end-over-end" agitation to the heating and cooling of canned food products. *Food Technol.*, 5, 457 (1951).
5. Havighorst, C. R. New canning process. *Food Eng.*, 25, 76 (1953).
6. Martin, W. M. Flash process, aseptic fill, are used in new canning unit. *Food Inds.*, 20, 832 (1948).
7. Vetter, J. L., Nelson, A. I., and Steinberg, M. P. Direct steam injection for high temperature short time sterilization of whole kernel corn. *Food Technol.*, 11, 271 (1957).

Notes and Letters

Performance of Flavor Judges in Long-Term Studies with Frozen Cauliflower and Spinach

In taste-tests involving long periods, it is of utmost importance that panel sensitivity remain reasonably constant throughout the tests. The purpose of the present study was to test panels at the beginning and end of 14-month studies with cauliflower and spinach to determine whether these panels met the constant sensitivity requirement. Duplicate samples from the first tests were held at −20° F for use in later trials. Cauliflower and spinach studies were independent; none of the judges had experience with the test products.

Following 15 training periods, the judges took the first test which was used for selection of panel members as well as for comparison with the final test. A test consisted of 10 repetitions by each judge on each of two pairs of samples. Each pair consisted of a control (held at −20° F) and a deteriorated sample (held at +20° F). Rank 1 for control was considered a correct decision. Since results for the two pairs were similar and number of judgments per pair was constant, results for the two pairs are combined in Figure 1. The 16 persons per vegetable who had 15 or more correct decisions were selected for panels. Comparison of the light and dark areas of the figure shows that judges with experience on other products performed no better on the average, than those who were completely inexperienced at the beginning of the study.

On completion of the 14-month investigation, the selected judges took the second test. Results for the two tests are summarized in Table 1. Chi-square tests on these data show that the extensive experience between tests did not result in statistically significant difference in number of correct decisions for either vegetable.

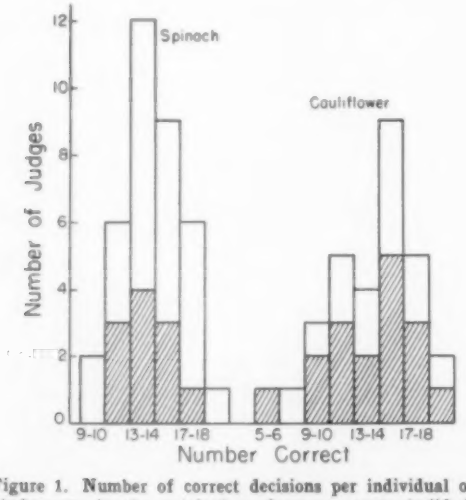

Figure 1. Number of correct decisions per individual out of 20 judgments in the original performance tests (solid blocks represent persons with flavor panel experience on other products).

TABLE 1

Comparison of per cent-correct decisions by selected panels at the beginning and end of fourteen-month studies[1]

Test	Per cent correct decisions			
	Spinach[2]		Cauliflower[3]	
	Control and 18 days at 20° F	Control and 30 days at 20° F	Control and 18 days at 20° F	Control and 28 days at 20° F
Beginning	76	85	73	89
End	71	82	79	84

[1] Approximately 450 pairs of main study samples were appraised in the 14 month interval between tests.
[2] Thirteen judges, 20 judgments per person.
[3] Fourteen judges, 20 judgments per person.

Performance scores calculated for each 30 consecutive pairs of the 450 pairs per vegetable in the 14-month studies showed that (a) the original tests closely estimated long-term performance of 14 of the 16 judges per panel, (b) with minor exceptions, each judge varied from time to time as much as different judges appraising at the same time and (c) each judge had very inconsistent results for at least one group of 30 pairs of samples.

Checking panel performance in prolonged investigations seems to the writers well worth the cost in time and materials.

The shape of the distribution curves in Figure 1 suggests an application of the study which was not anticipated, but which is of interest. In taste-tests requiring only that judges match duplicates among 3 samples, the curves would represent primarily the thresholds of the individuals, and the central areas of the curves would represent individuals with medium thresholds, that is, it would exclude individuals with unusually high and low thresholds. Such curves therefore might be useful in selecting panels of similar sensitivity in different laboratories. It is hoped that this theory may at least stimulate interest in the difficult problems involved in standardization of the measuring tool in taste-tests.

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March 17, 1960.

Moisture Loss from Packages of Frozen Vegetables

In the course of an extensive study on the time-temperature tolerance of frozen vegetables at this laboratory *(7)* the question arose as to whether moisture loss was important, since most packages were exposed singly in moving air to determine rates of deterioration. It was observed that some lots became desiccated when held for long periods at low temperatures or for shorter periods above 15° F. Procedures and observations in this note are submitted to supplement the information on product stability of frozen peas, green snap beans, and spinach described *(1, 2, 3)* and current tests on cauliflower.

Packaging materials and tests for moisture loss as related to frozen foods have been reviewed by Tressler and Evers *(6)*. More recently Winter *et al (8)* have determined weight loss in a number of frozen foods stored in various packaging materials other than the usual waxed paper carton.

Materials and Methods. Vegetables in waxed-paper cartons overwrapped with wax paper(8- to 10-oz) were subjected to several constant temperature conditions in the range −20° to 30° F, and to cyclic fluctuating temperatures of −10° to 10° and 0° to 20° F[a] during the study of other factors *(7)*. Single packages from each of 2 lots of peas, beans, and spinach, and 7 lots of cauliflower were placed on their narrow side and about 1 in apart on shelves exposed at all times to uniform air circulation in rooms described by Lowe *et al (5)*. On the basis of the narrow difference in temperature between refrigeration coil and air, the constant-temperature rooms would have a relative humidity of 75 to 90%, depending on refrigeration load. In some instances, samples were left in their original cases (24 pkg) during the time they were held at elevated temperatures. Usually a different set of packages was examined at each time period.

Weights of single or groups of 3 to 20 packages, were recorded on transfer from −20° F to the higher temperature condition under investigation and on return to −20° F. A 5-kg computagram scale with a 500-g capacity chart and 1-g gradations was used to weigh packages to the nearest 0.5 g, after frost or condensed moisture had been removed from the outside. More precise weighings of the different wax paper overwraps were made at the time of analysis and the pounds per ream (3000 sq ft) calculated.

In addition, small lots of peas, corn, leaf spinach, chopped spinach, green beans, shredded potatoes, and cooked squash in conical waxed paper tubs were tested for moisture loss when held at 20° F for more than a year.

Results. Average rates of moisture loss in per cent per day for single packages of spinach and cauliflower are graphed in Figure 1 as functions of temperature. These rates increase roughly one and a half times per 5° F rise in temperature between 0° and 20° F. The maximum time periods used in these studies were 2 years at 0°, 1 year at 10°, and 4 or 8 months at 20° F. Rates of moisture loss in 4 additional lots of cauliflower held in single packages at 10° and 20° F closely paralleled those shown in Figure 1. Essentially no loss of moisture occurred in any cased control samples held at −20° F over a 2-year period.

[a] Controlled by a sine wave cam, 24-hr cycle.

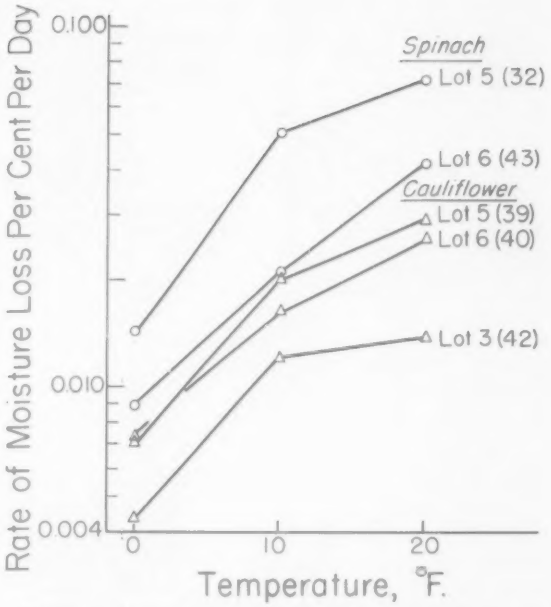

Figure 1. Rate of moisture loss versus temperature. Percentages are calculated on net weight exclusive of packaging material. Numbers in parenthesis are weight of wax paper overwrap in pounds per ream.

For comparison, rates of moisture loss from cased and single packages are given in Table 1 for a cycled and 3 constant temperature conditions. Rates for cased packages were half or less than half that found for single packages exposed under the same temperature conditions. Packages of spinach and cauliflower exposed to the 0° to 20° F cycle lost moisture a little faster than samples held at constant 10° F, as expected from previous discussions *(2)*.

In general, the heavier wax paper overwrap reduced the rate of moisture loss, although an occasional reversal was observed. Two overwraps for peas weighed 32 and 45 lb per ream and two for spinach

TABLE 1

Rate of moisture loss of cased versus single packages

Vegetable	Temperature	Cased	Single
	°F	*Per cent loss/day*	*Per cent loss/day*
Peas	−10 to 10[1]	.011	.042
Peas	−10 to 10[1]	.004	.013
Beans	−10 to 10[1]	.005	.012
Cauliflower	−10	.001	.007
Cauliflower	0	.004	.007
Cauliflower	20	.008	.014
Cauliflower	20	.016	.029
Spinach	20	.023	.072
Spinach	20	.020	.042

[1] 24-hr cycle.

weighed 32 and 43 lb per ream. Bean and cauliflower overwraps did not differ by more than 5 lb per ream. The spinach and cauliflower with the lighter overwrap (Figure 1) had the higher rate of moisture loss.

Even though the carton weights varied over a range of 219 to 243 lb per ream, no systematic relationship was apparent between weight of carton board and the rate of moisture loss for the vegetables examined. The need for an overwrap has been demonstrated by Klein *(4)* who stored peas for 6 months at 0° F and found a 0.05% weight loss per day in cartons with no overwrap, but only a 0.003% per day weight loss when Tyton waxed paper overwrap was used.

Similiar rates of moisture loss were found for vegetables held in conical waxed paper tubs at 20° F. As the tub size increased from 4 oz to 10 lb, the average weight loss increased linearly from 0.042 g to 0.344 g per day. When rates were expressed as per cent loss per day, values were 0.014, 0.0084, and 0.0076 for 1-, 5-, and 10-lb tubs respectively.

The lightest wrapped product in rectangular cartons (spinach, Lot 5), had lost 5 to 7% net moisture after 2 months at 20° F, and desiccation was noticeable over 50 to 75% of the surface exposed to package airspace. A comparable loss at 0° F required 8 months.

Although weight loss was less, the heavier-wrapped sample of spinach, Lot 6, and 3 lots of cauliflower did show a transfer of moisture out of the product with the formation of ice crystals on the inside walls of the package after extended holding. When desiccation was apparent, considerable conversion of chlorophyll to pheophytin in spinach *(3)* and browning in cauliflower had already occurred, together with a substantial loss of ascorbic acid and general deterioration in quality of both products. Therefore, in view of these changes it seems unlikely that desiccation could play a major role in quality deterioration under commercial conditions provided packaging materials were not more permeable to moisture.

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[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

LITERATURE CITED

1. BOGGS, MILDRED M., DIETRICH, W. C., NUTTING, MARVEL-DARE, OLSON, R. L., LINDQUIST, F. E., BOHART, G. S., NEUMANN, H. J., AND MORRIS, H. J. Time-temperature tolerance of frozen foods. XXI. Frozen peas. *Food Technol.*, **14**, 181 (1960).
2. DIETRICH, W. C., NUTTING, MARVEL-DARE, OLSON, R. L., LINDQUIST, F. E., BOGGS, MILDRED M., BOHART, G. S., NEUMANN, H. J., AND MORRIS, H. J. Time-temperature tolerance of frozen foods. XVI. Quality retention of green snap beans in retail packages. *Food Technol.*, 13, 136 (1959).
3. DIETRICH, W. C., BOGGS, MILDRED M., NUTTING, MARVEL-DARE, AND WEINSTEIN, N. E. Time-temperature tolerance of frozen foods. Quality changes in frozen spinach stored in retail packages. Presented at the 19th Annual Meeting of Institute of Food Technologists, Philadelphia, May 17–21, 1959.
4. KLEIN, MARIAN G. Indications for carton overwraps. *Modern Packaging*, **31** (12) 125 (1958).
5. LOWE, E., SMITH, G. S., BARTA, E. J., ROCKWELL, W. C. Specialized research facilities determine temperature tolerance of frozen foods. *Refrig. Eng.*, **66**, 51 (1958).
6. TRESSLER, D. K., AND EVERS, C. F. *The Freezing Preservation of foods.* 3d ed. 1957. Chap. 8 and Appendix, Part 5.
7. VAN ARSDEL, W. B. The time-temperature tolerance of frozen foods. I. Introduction. The problem and the attack. *Food Technol.*, **11**, 28 (1957).
8. WINTER, J. D., AND TRANTANELLA, SHIRLEY R., AND HUTCHINS, A. E. Polyethylene laminates, glass, score high in frozen peas, asparagus packaging tests. *Quick Frozen Foods*, **21** (1) 28 (1958).

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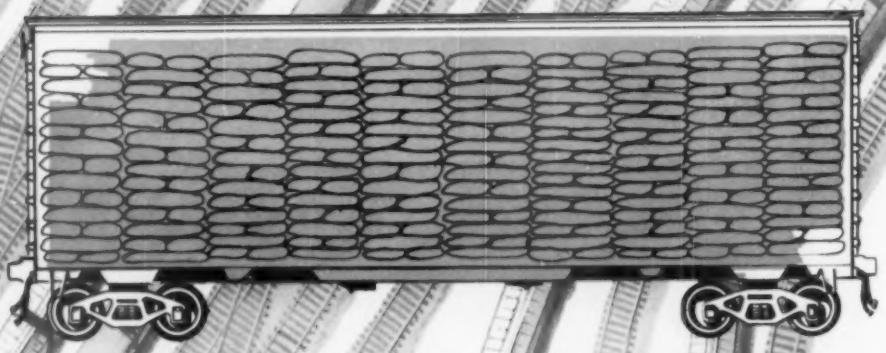

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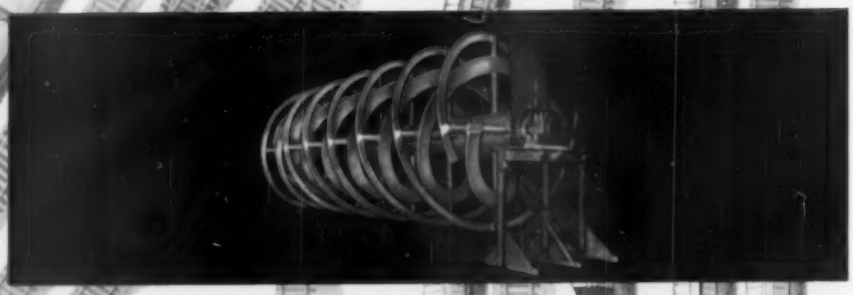

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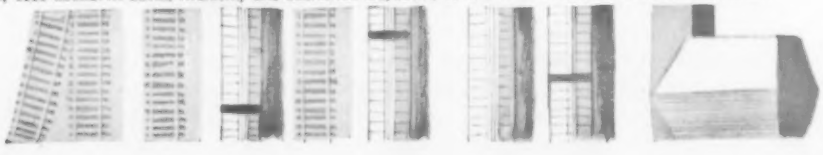

MOHAWK VALLEY

The future success of the processed food industry will depend upon how diligently it continues to develop new and better products according to James G. Moore of the Blaw-Knox Company's Buffovak Equipment Division, Buffalo, who spoke before the Section on March 17, 1960.

J. G. Moore

The high quality dry "instant" product, through its public acceptance, holds special promise for rapid growth, and concentrated food research effort in this particular field is being made by many processors. Because of this growing demand for dried foods, the unit operations of evaporation and drying have special significance. Now, more than ever before, consideration is being given to variations in operating techniques, and new applications of conventional equipment as well as radically new designs.

The acceptance of the time vs temperature concept in all fields of food processing, especially evaporation and drying, and its complete understanding have paved the way for new equipment application. This has enabled the successful use of equipment heretofore considered unsatisfactory for the processing of so-called heat sensitive materials.

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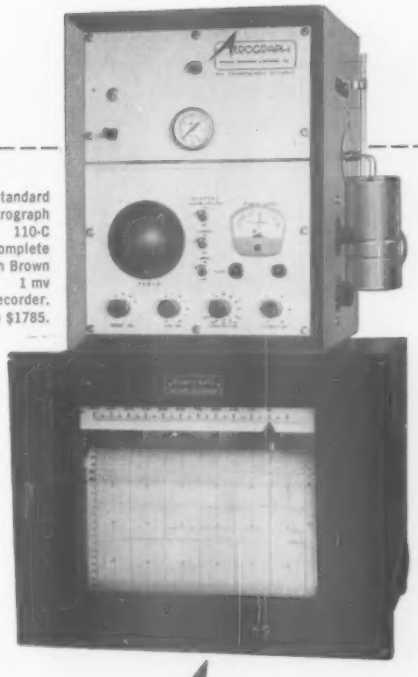

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easily controlled, modified, and operated, while requiring moderate quantities of materials, yet it must be sufficiently large to have operating problems comparable to, and yield results indicative of commercial size units. The Blaw-Knox, Buflovak Equipment Division Laboratory, at Buffalo, has test equipment of sufficient size to yield results which can be extrapolated and guaranteed without reservation, Mr. Moore stated.

When an equipment design organization, equipped with an extensive development laboratory and a working knowledge of the requirements of the food industries, initiates research programs specifically directed toward some particular segment of the process field, it becomes inevitable that product technology and equipment design go hand in hand, and a certainty that new food products and processes, as well as revised equipment designs, evolve.

Mr. Moore reported that as a result of internally sponsored research at Buflovak, new food products have come into existence. Dry Vital Wheat Protein (Gluten) made by a new instantaneous single pass process; Instant Tea, made by continuous extraction, evaporation and drying; Dry Colorless Granular Corn Syrup Solids; and Dry Tomato Paste are a few of the new products developed.

Research must be continued in those areas of equipment design which will result in realistic and economical food products and processing techniques. This realization should guide the thinking for new equipment application so that economical quality food products, and not laboratory curiosities, result.

Literature

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY[a]

[a] Material for this list should be sent to Walter L. Necker, Librarian, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

General

Dostizheniia michurinskoi nauki v mikrobiologii, ed. by S. N. Muromssev. (Congress of Microbiology). Moscow, 1958. 228 p., illus.

Gas-Chromatographie, by Rudolf Kaiser. Leipzig, Geest & Portig, 1960. 223 p., illus.

Die Küche unterm Mikroskop; Forscher ergründen Macht und Geheimnis der Nahrung. Düsseldorf, Econ Verlag, 1959. 368 p., illus.

Mikrobiologicheskoe issledovanie . . . pishchevykh produktov, by S. P. Askalonov. (Bacteriology of Food). Kiev, 1959. 33 p., illus.

Nucleoproteins (Instituts Solvay Symposium at Brussels, 1959). New York, Interscience Publishers, 1960. 364 p., illus.

Techniques of polymer characterization. Peter W. Allen, ed. London, Butterworths. 256 p., illus.

Texture in foods; a symposium held in London, 1958. Society of Chemical Industry, 1960. iv, 184 p., illus.

Products

Handbook of cane sugar engineering, by Emile Hugot. Princeton, VanNostrand (Elzevier). 872 p., illus. 1960.

Regulations governing the meat inspection of the U. S. Department of Agriculture. Washington, Agricultural Research Service, 1960. 242 p.

Survey of fruit cool stores, by G. M. Rostos. Melbourne, Commonwealth Scientific and Industrial Research Organization, 1960. 76 p., illus.

Wurst Rezepte Buch, by Fritz Schwarz. Wien, Leinmüller, 1958. 173 p.

ABSTRACTS

General Foods Research Center
Selected by H. A. Campbell

ANALYTICAL METHODS

Informal gas chromatography symposium.

BRANDT, W. W. (Purdue Univ., Lafayette, Ind.). *Anal. Chem. 32*, 339–40 (1960).

The author offers a concise review of the informal discussion on gas chromatography which took place under sponsorship of the Division of Analytical Chemistry at the national meeting of the American Chemical Society in Atlantic City last fall.

Analysis of fats and oils by gas-liquid chromatography.

HERB, S. F., MAGIDMAN, P. AND RIEMENSCHNEIDER, R. W. (Eastern Regional Research Lab., Philadelphia, Pa.). *J. Am. Oil Chemists' Soc. 37*, 127–9 (1960).

Known mixts. of pure fatty acid methyl esters and a number of fats and oils as their methyl esters have been analyzed by conventional GLC with thermal conductivity detectors. Percentage of fatty acid distribution detd. by GLC agreed well with known percentages in model mixts. and with analysis by the spectrophotometric method for fats and oils. Detn. of very small amts. of arachidonic and pentaenoic acids in lard by GLC was not successful.

Retention temperature and column efficiency in programmed temperature gas chromatography.

HABGOOD, H. W. AND HARRIS, W. E. (Univ. of Alberta, Edmonton, Can.). *Anal. Chem. 32*, 450–3 (1960).

A theoretical consideration of linear programmed temp. gas chromatography shows that with only minor approximations the retention of a solute may be readily predicted from isothermal gas chromatographic data. This was confirmed experimentally. While the retention may be expressed in the usual way as a retention vol., there are advantages in characterizing each peak by its retention temp. For any given column this retention temp. depends on the ratio of heating rate to carrier gas flow rate rather than on either one alone. An equation for the calcn. of column efficiencies in programmed temp. gas chromatography is also presented.

Spectrophotometric detection of the end point in the Karl Fisher titration of water.

CONNORS, K. R. AND HIGUCHI, T. (Univ. of Wisconsin, Madison). *Chemist-Analyst 48*, 91–2 (1959).

With the introduction of a photometric titration circulation unit and the increasing interest in photometric titrations, a further study of the spectrophotometric detection of the end point in the Karl Fisher titration was warranted. It has been established that by this approach water concns. of less than 0.01% can be detd. with a precision at about 0.0003%.

Immunoelectrophoresis.

WILLIAMS, C. A. *Sci. American 202*, 130–40 (Mar. 1960).

The author describes the contributions made by himself and other investigators to the development of immunoelectrophoresis. This new method combines electrophoresis and immunochemistry by first segregating proteins according to their electrophoretic mobility and then identifying them by the highly specific immune reaction. Protein fractions can be identified from curved line formed on agar gel by the ppt. of the antigen-antibody reaction. Ability to det. smaller amts. than other electrophoretic techniques and the enhanced resolving power of immunoelectrophoresis have opened new avenues of research in embryology, bacteriology and pathology.

The structures of synthetic molecular sieves.

BROUSSARD, L. AND SHOEMAKER, D. P. *J. Am. Chem. Soc. 82*, 1041–51 (1960).

The crystal structures of synthetic molecular sieves have been detd. in their hydrated forms (contg. 25–35 wt. % H_2O). These studies show that all 3 sieves have a common building block

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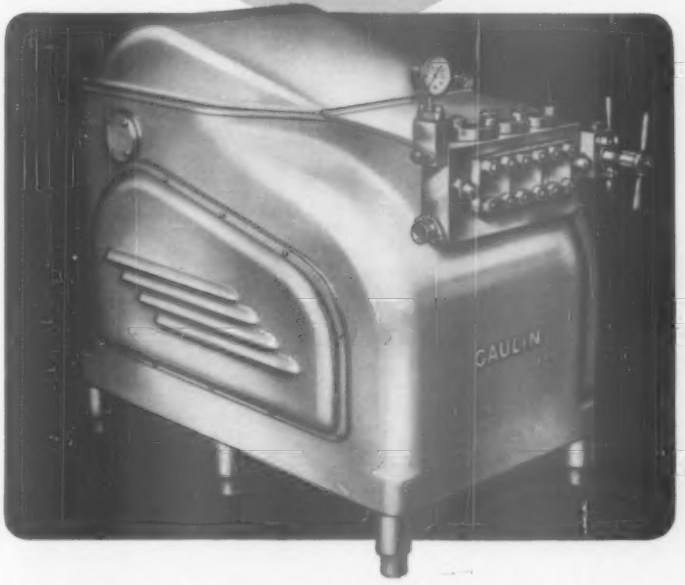

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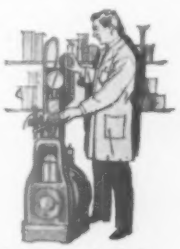

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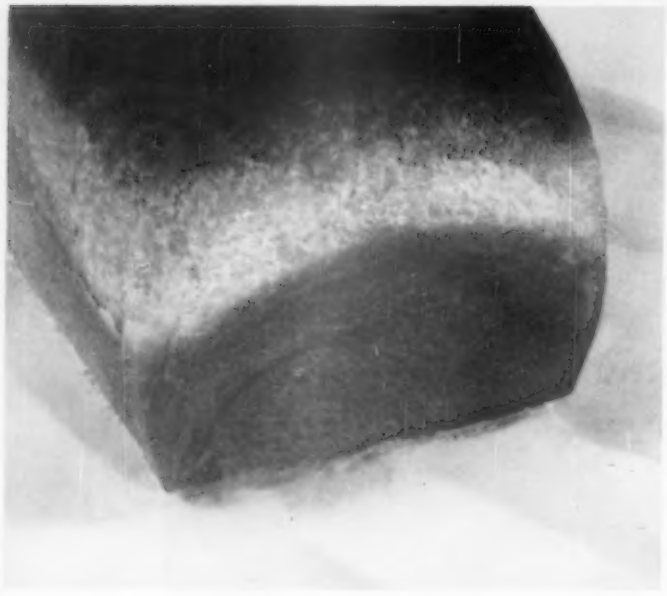

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called a "sodalite" unit, contg. 24 (Si, Al) ions interconnected with 36 oxygen ions. These sodalite units are arranged in a simple cubic array, with each sodalite unit connected to its neighbor by 4 bridge oxygen ions. Sodalite units may also be in tetrahedral coordination (diamond array) with each sodalite unit connected to its neighbor by 6 bridge oxygen ions.

BIOLOGICAL SCIENCES

Biochemistry

Purification of pepsin by gel filtration.

GELOTTE, B. AND KRANTZ, A. (Research Labs., Pharmacia, Uppsala, Sweden). *Acta Chem. Scand. 13*, 2127 (1959).

The cross-linked polysaccharide Sephadex G-50 (mfd. by Pharmacia, Uppsala, Sweden) was used as bed material in the sepn. of molecules of different size. When the soln. is filtered through the column of swollen gel grains, solutes of large molecular size are prevented from entering the gel phase and move in the aq. phase surrounding the grains. Low molecular wt. solutes, penetrate the gel phase and pass the column in the water inside as well as outside the grains. They are therefore eluted from the column later than the larger ones. The method is very useful for desalting colloid solns. and for fractionation of polymer homologues. Typical results using pepsin as starting material are shown.

Rotary behavior of protein denaturation.

IMAHORI, K. (Univ. of Tokyo, Japan). *Biochim. et Biophys. Acta 37*, 336–41 (1960).

Reversible and irreversible denaturation processes were examd. by rotatory dispersion. Samples of bovine serum albumin that were submitted to reversible denaturation by urea attained their original conformation after removal of the denaturing agent. In the irreversible denaturation all proteins were completely unfolded or slightly assocd. in the β-form in the presence of denaturant. But after the removal of the denaturant striking formation of the β-form was observed. The reversibility of the denaturation seems to depend on the nature of the solvent.

Studies on the synthesis of serum albumin by the isolated microsome fraction from rat liver.

CAMPBELL, P. N., GREENGARD, O. AND KERNOT, B. A. (Middlesex Hosp., London, Engl.). *Biochem. J. 74*, 107–17 (1960).

The microsomal fraction from regenerating rat liver was incubated with radioactive amino acids, adenosine triphosphate, phosphoenolpyruvate and cell sap. The microsomes were sepd. from the sol. proteins and were disintegrated with ultrasonics. The rat albumin released from the microsomes and in the soluble fraction of the incubation mixt. was pptd. by the addn. of an antiserum and its radioactivity was detd. The results indicated that there was an incorporation of amino acids into the microsomal albumin but not into the albumin in the medium. It is also concluded that the results are consistent with the hypothesis that isolated rat-liver microsomes are able to synthesize albumin but that this albumin is not released in a soluble form.

An enzymatic spectrophotometric method for the determination of phenylalanine in blood.

LA DU, B. N. AND MICHAEL, P. J. (Natl. Insts. of Health, Bethesda, Md.). *J. Lab. Clin. Med. 55*, 491–6 (1960).

A simple enzymatic spectrophotometric method has been described for the quant. detn. of phenylalanine in serum. The method is based upon the measurement of the absorption of the enol-borate complex of phenylpyruvic acid generated enzymatically from phenylalanine by L-amino acid oxidase of snake venom. For elevated serum levels of phenylalanine the method is rapid, specific, and precise. It should be useful as a confirmatory test in the diagnosis of suspected phenylketonuria and in the evaluation of the effectiveness of a diet low in phenylalanine. 14 references.

Paper chromatography of heparin and related sulfated mucopolysaccharides.

SPOLTER, L. AND MARX, W. (Univ. of Southern California, Los Angeles). *Biochim. et Biophys. Acta 38*, 123–9 (1960).

A paper chromatographic system was developed for the resolution of mixts. of sulfated mucopolysaccharides. The effect of varying the ammonium formate buffer/isopropanol ratio in the developing soln. on the R_f values of heparin and chondroitin sulfate is presented. A complete sepn. of heparin from chondroitin sulfate was obtained with 3 solvent mixts. contg. different proportions of buffer and isopropanol.

Changes in molecular weight of acid mucopolysaccharides in connective tissue due to hormone treatment, dehydration and age.

HVIDBERG, E. AND JENSEN, C. E. (Univ. of Copenhagen, Denmark). *Acta Chem. Scand. 13*, 2047–56 (1959).

Acid mucopolysaccharides have been isolated from animal skin and characterized by means of viscosimetry, chromatography and metachromasia. It is shown that the molecular wt. of these substances decreases with age. A depolymerization of these substances apparently also takes place during severe dehydration and under the influence of cortisone, while estradiol treatment results in a polymerization. Thus, the size of the hyaluronic acid molecule is an important factor in the waterbinding mechanism of connective tissue.

Liver choline oxidase activity in man and in several species of animals.

SIDRANSKY, H. AND FARBER, E. (Natl. Insts. of Health, Bethesda, Md.). *Arch. Biochem. Biophys. 87*, 129–33 (1960).

Choline oxidase activity was investigated in the livers of rats, mice, chickens, dogs, hamsters, rabbits, guinea pigs, monkeys, and human beings. Marked species differences were observed. In animals the rat has the highest activity while the guinea pig has the lowest activity. Choline oxidase activity in livers from human biopsy and autopsy material was lower than in any species studied. A possible correlation between the level of hepatic choline oxidase in each species and the ease of induction of choline-deficient fatty liver is discussed.

Pectic metabolism of growing cell walls.

JANSEN, E. F., ET AL. *Plant Physiol. 35*, 87–97 (1960).

The auxin-induced chemical changes in pectin and other components of the cell walls of oat coleoptiles are studied in quant. detail. Incubation of tissue with indolacetic acid induced an accelerated formation of the methyl ester of the pectic substances of cell walls, although no analytically detectable net change in cell wall content of pectic substance, in methyl ester content, or in degree of pectic esterification was found. The cell walls contained a considerable amount of labile alkyl groups other than methyl ester. The nature of these alkyl groups is not now known. It is also shown that auxin increases the turnover of methyl ester groups of the pectic material not directly assocd. with the cell wall to a greater extent than that of the cell wall.

Microbiology

Precooked frozen foods and the new handling code.

ROBERTSON, A. H. (Dept. of Agr. and Markets, Albany, N. Y.). *J. Milk & Food Technol. 23*, 54–8 (1960).

The origin of and membership in the Assocn. of Food and Drug Officials of the United States is described. Operations are surveyed including bacterial detns. on products at different stages of processing in several precooked frozen food processing plants. Any product consisting in part of meat, poultry, gravy, sauce or stuffing is readily subject initially to plant mishandling and should be processed with minimal delay. Sanitarians are urged to be practical, understanding, cautious and conservative when

using the new tools in the recommended code; nevertheless, industry's familiarity with and early use of it will do much to maintain frozen food quality at a high level.

Present problems in high-heat pasteurization processes.

ROBINSON, H. B. (U. S. Dept. of Health, Educ., and Welfare, Washington, D. C.). *J. Milk & Food Technol. 23*, 49–53 (1960).

The present problems in pasteurization of milk and milk products at temps. above 190° F. with holding times of 1 second are: (a) a need for further research on the thermal destruction of significant microorganisms in this temp. range to define the limits of safety inherent in the process; (b) a need for development of specifications for equipment and controls which will assure proper pasteurization under all conditions of operation, including those resulting from abrupt failure of primary heat and power; and (c) recognition and control of related problems such as those presented by use of direct steam heating.

Microscopy

Simple ultramicro-pipette for electron microscopy.

HARDY, R., MAJER, J. R. AND TRAVERS, S. (Univ. of Birmingham, Engl.). *J. Sci. Instr. 37*, 103–6 (1960).

A design for an ultramicro-pipette which permits the controlled delivery of droplets down to 2 μ in diameter is described. After measurement by means of a screw-micrometer eyepiece, the droplets are deposited directly upon film-covered electron-microscope grids by means of a micro-manipulator. This technique allows particle counts of suspensions of submicroscopic particles to be made with greatly increased precision.

Nutrition

Acceleration of essential fatty acid deficiency by dietary cholesterol.

HOLMAN, R. T. AND PEIFER, J. J. (Univ. of Minnesota, Austin). *J. Nutrition 70*, 411–17 (1960).

The inclusion of 1% of cholesterol in an EFA-free diet accelerates the appearance of dermal signs of essential fatty acid deficiency in rats. That dietary cholesterol accentuates EFA deficiency is indicated by a lowered food efficiency, lower wt. gain, retardation of testicular development and an accentuated polyunsatd. fatty acid pattern of heart lipides.

Time of occurrence of changes in the liver's capacity to utilize acetate for fatty acid and cholesterol synthesis after fat feeding.

HILL, R., ET AL. (Univ. of California, Berkeley). *J. Lipid Research 1*, 150–3 (1960).

The time relationships in the changes in hepatic lipogenesis and cholesterogenesis induced by the feeding of corn oil and lard have been studied. A pronounced decrease in the capacity of the liver to convert acetate carbon to fatty acids was observed as early as 1 hour after fat administration. The increase in the liver's capacity to incorporate acetate carbon into cholesterol developed slowly after fat feeding; the earliest change was observed in 12 hours.

Diet-type (fats constant) and blood lipids in man.

KEYS, A., ANDERSON, J. T. AND GRANDE, F. (Univ. of Minnesota, Minneapolis). *J. Nutrition 70*, 257–66 (1960).

Controlled expts. were carried out on men with diets differing in the proportions of carbohydrate calories supplied from various food sources. It was concluded that sucrose and milk sugar tend to produce higher serum cholesterol values than equal calories of carbohydrates contained in fruits, leafy vegetables and legumes.

Effect of carbohydrate source on cholesterol and cardiovascular system.

ANON. *Nutrition Revs. 18*, 88–90 (1960).

Rabbits fed lactose and cholesterol developed significantly more aortic atheroma, with higher serum and hepatic cholesterol levels, than did rabbits fed sucrose and cholesterol.

The influence of exogenous iron on formation of hemoglobin in the premature infant.

HAMMOND, D. AND MURPHY, A. (Univ. of California, San Francisco). *Pediatrics 25*, 362–74 (1960).

Premature infants can utilize exogenous iron at very early ages before naturally acquired iron stores are depleted. Early administration of iron appears to accelerate recovery from the early anemia of prematurity. Dietary sources alone appear adequate for prevention of the late anemia in most premature infants receiving diets of superior nutritional quality.

Supplementation of cereal proteins with amino acids. III. Effect of amino acid supplementation of wheat flour as measured by nitrogen retention of young children.

BRESSANI, R., ET AL. (Inst. of Nutrition of Central America and Panama, Guatemala). *J. Nutrition 70*, 176–86 (1960).

Data from a nitrogen-balance study showed that the nutritive value of wheat proteins can be greatly improved by the addn. of lysine alone to the wheat diet. Apparently, however, more consistent results are obtained if tryptophan is added together with lysine.

The copper content of infant foods.

HUGHES, G., KELLY, V. J. AND STEWART, R. A. (Gerber Products Co., Oakland, Calif.). *Pediatrics 25*, 477–84 (1960).

The copper content of 86 baby food items is given with method used. It is concluded that the copper intake provided by "average" diets contg. processed baby foods meets or exceeds the estimated daily requirement of 0.05 mg./kg. of body wt./day.

Effect of suboptimal intakes of B vitamans on protein utilization by the growing rat from diets containing single and mixed proteins.

MARFATIA, U. AND SREENIVASAN, A. (Univ. of Bombay, India). *J. Nutrition 70*, 163–70 (1960).

Sub-optimal and optimal concns. of 7 B vitamins were used in purified diets in two series of expts. with the albino rat. Growth data showed that differences in the growth rate due to type of protein narrowed with optimal intake of vitamins. There seems to be an inverse relationship between protein quality and the effectiveness with which B vitamins can be used at higher levels.

Effects of excesses of thiamine and pyridoxine.

ANON. *Nutrition Revs. 18*, 95–6 (1960).

A study was made to det. if excessive intake of pyridoxine and thiamine by female rats during pregnancy increased the infant requirement for pyridoxine after birth. Results showed that the rates of growth and the efficiency of food utilization in the mother were not affected by excess doses of the vitamins, and the av. size, survival and growth of the offspring were unchanged as well.

Toxicology

Retarding action of nordihydroguaiaretic acid on aging of rats.

BUU-HOI, N. P. AND RATSIMAMANGA, A. R. Compt. rend. soc. biol. *153*, 1180–2 (1959).

Feeding this antioxidant, 20 mg./kg. of ration, significantly increased the life span of male and female rats and increased the no. of litters borne by the females during their lifetime, as compared with untreated littermate controls.

Lack of relationship between body weight and pharmacological effect exemplified by histamine toxicity in mice.

ANGELAKOS, E. T. (Boston Univ., Mass.). *Proc. Soc. Exptl. Biol. Med. 103*, 296–8 (1960).

Data from 360 mice are presented which show that the toxicity of intraperitoneal histamine is independent of body weight. Adjustment for body wt. in the range of 15 to 25 g. increased the variation so that smaller animals appeared to be less sensitive to histamine than larger mice. Possible mechanisms are discussed.

The plant hormones—Their occurrence in foods and possible role in human physiology.

VLITOS, A. J. *Borden's Rev. 21*, 13–26 (1960).

Since several groups of substances with plant growth regulating activity occur in foods it is very likely that, upon ingestion, these compds. undergo a sequence of metabolic changes. Whether or not the metabolic intermediates are important in human physiology remains for further research to determine. Indole ring-contg. compds., such as serotonin, have assumed important physiological roles in the human. However, it is doubtful whether there is any clear-cut link between consumption of foods rich in indolic precursors and any subsequent increase in serotonin levels in the body.

FOOD AND FOOD TECHNOLOGY

Antioxidants

Action and detection of natural fat antioxidants.

SERZISKO, R. AND TAUFEL, K. *Ernahrungsforschung 4*, 484–99 (1959).

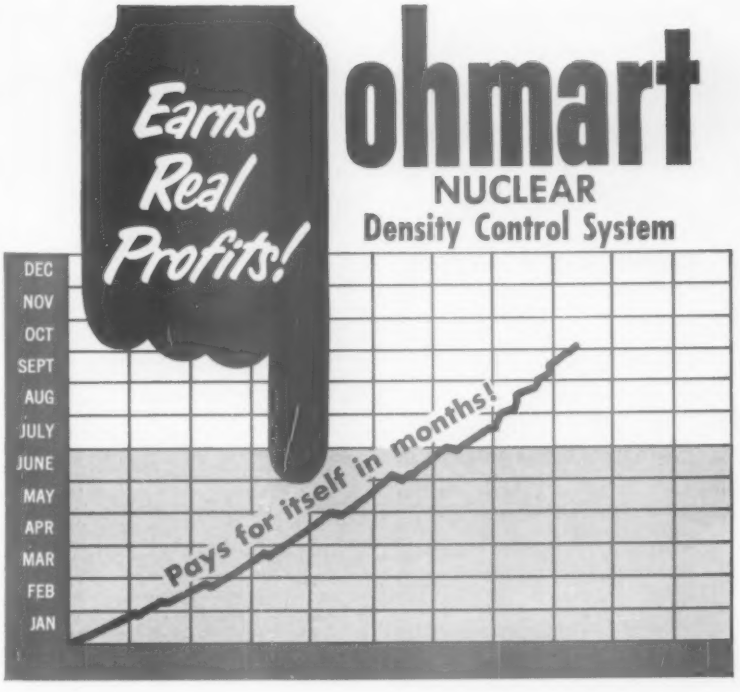
The antioxidizing effects of exts. of comm. raw materials (cocoa husks, wheat germs, soya, pepper, tomatoes) were investigated and expressed as peroxide number. The exts. were further examd. paper chromatographically for tocopherol.

Cereals and Grains

The physical structure of wheat protein.

GROSSKREUTZ, J. C. (Midwest Research Inst., Kansas City). *Biochim. et Biophys. Acta 38*, 400–9 (1960).

The physical structure of wheat proteins has been investigated using both wide- and small-angle X-ray scattering and electron microscopy. Dry wheat gluten, gliadin and the water-sol. proteins all give similar wide-angle diffraction patterns characteristic of folded polypeptide chains in the α_1-helix configuration. Small-angle scattering curves from stretched, dried glutens show marked orientation and can be interpreted in terms of parallel sheets of gluten platelets whose thickness does not



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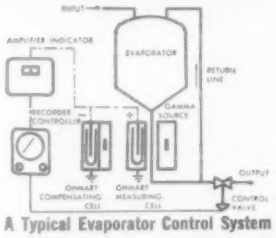

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exceed ~ 70 A. Electron micrographs taken of surface replicas of the stretched glutens confirm the sheet structure. Moist, relaxed glutens, while not exhibiting the orientation into sheets, still give the X-ray scattering characteristic of platelets.

Coffee and Tea

Analysis of the volatile constituents of coffee.

RHOADES, J. W. (Southwest Research Inst., San Antonio, Tex.). *J. Agr. Food Chem. 8*, 136–41 (1960).

Studies on the roasting of 7 varieties of coffee show that generally the concn. of volatiles in the bean increases with increased roasting. Hydrogen sulfide, methyl formate, and acetyl propionyl reach a max. concn. within the normal roasting temps. The concn. of dimethyl sulfide remains essentially const. during the roasting process. Analysis of green beans shows differences which may be useful in typing or grading green coffee. In roasted coffee, the ratio of diacetyl to acetyl propionyl may be indicative of the degree of roast. Analysis of brewed coffee shows the concn. of volatiles to be in the range of 1 to 2000 p.p.b.

Method of making a tea extract.

SELTZER, E. AND SAPORITO, F. A. Assignors to Thomas J. Lipton Inc. U. S. 2,927,860. Mar. 8, 1960.

Provides for an improvement in the process of making a concd. tea product from an aq. ext. of tea leaves. Dilute aroma vapors are distilled from the tea ext. at 150° F. in an evaporator under a vacuum so as to preserve the quality of the tea flavor. The dilute aroma vapors are condensed and highly concd. by a fractionating column. The dilute aroma vapors are fed continuously to the column while applying heat to the base of the column to strip aroma from the fluid flowing down the column and to force it out the top of the column as vapor. The vapor is condensed and returned to the top of the column to maintain a high concn. of aroma in the condensate. A minor portion of the condensate is removed and combined with the tea ext. which has meanwhile been concd. by the removal of water.

Dehydration

Evaporation from drops containing dissolved solids.

CHARLESWORTH, D. H. AND MARSHALL, W. R. (Univ. of Wisconsin, Madison). *Am. Inst. Chem. Eng. J. 6*, 9–23 (1960).

A study was made of the evapn. from single drops contg. solids. By means of a specially designed sensitive balance, drops were suspended over a hot-air stream and their drying behavior was observed. Weight changes were measured during evapn. Exptl. data are presented on the time of appearance of the first solid phase and the formation of a solid crust for a wide range of drying conditions and materials. A theory is advanced for predicting the formation of a solid phase in drying a droplet contg. a dissolved solid.

Up-grading of low-grade meat.

PENNY, I. F. *Chem. & Ind.* 288–9 (1960).

Accelerated freeze-drying process coupled with the use of enzymes is suggested as a possible method for utilizing low-grade meat. The enzyme can easily and evenly be absorbed throughout the porous structure of the freeze-dried meat. Dried steaks prepd. from cow meat which was tough to the point of inedibility, reconstituted in tenderizer soln. and cooked in a casserole for two hours were found by taste panels to be very acceptable. The most satisfactory enzymes were ficin at a concn. of 0.0025% and papain at 0.005%.

Fats and Oils

The unsaturated fatty acids in menhaden body oil: the C_{18}, C_{20}, and C_{22} series.

STOFFEL, W. AND AHRENS, E. H. (Rockefeller Inst., New York). *J. Lipid Research 1*, 139–46 (1960).

Complete structural characterization of the C_{18}, C_{20}, and C_{22} unsatd. acids of menhaden body oil is described. The present report bring to 23 the number of chemically defined unsatd. acids in this oil, accounting for 98% of the total wt. of unsatd. acids. Of these 23 acids, 7 have not previously been reported. Pure acids (or mixts. of positional isomers) were isolated. Studies of this complex oil, which is composed of more than 44 different acids, provide convincing evidence of the great usefulness of gas-liquid chromatography as a preparative and analytical procedure. Chemical characterization studies are now feasible on a microscale.

Legislation

The new additive regulations for Western Germany. I.

HINTON, C. L. *Food* (British) *29*, 83–5 (1960).

This summarizes the essential features of the food additives law adopted by West Germany in Dec. 1959. Lists of preservatives and the foods to which they may be added are given along with tables of the max. amts. allowable.

Milk and Milk Products

Reconstitutability of dried whole milk. I. The effect of sinkability of the manner of handling freshly dried milk.

BULLOCK, D. H. AND WINDER, W. C. (Univ. of Wisconsin, Madison). *J. Dairy Sci. 43*, 301–16 (1960).

A test has been devised which adequately measures the variations in the sinkability of dried whole milk, a characteristic related to the reconstitutability. The sinkability of dried milk was greatly affected by the manner in which the dried milk was handled after drying. Maximum sinkabilities were maintained when the dried milk was well chilled before the dried milk particles were allowed to rub against each other or any object. A temp.-conditioning treatment was developed which allowed the recovery of th initial sinkability possessed immediately after drying. This phenomenon was attributed to the physical arrangement of the glycerides of the surface fat on the dried milk particles.

Free and bound lactose in milk.

DUTRA, R. C., JENNINGS, W. G. AND TARASSUK, N. P. (Univ. of California, Davis). *J. Agr. Food Chem. 8*, 143–4 (1960).

By using both isotope diln. methods and a conventional protein pptn. technique, it was demonstrated that in unheated milk, 0.54% lactose is assocd. with milk protein(s). The assocn. is apparently weak, as all lactose is removed from unheated milk by dialysis for 72 hrs. The results suggest reversible equilibrium between free and bound lactose favoring a free-bound ratio of about 8 to 1. Binding of lactose by heated proteins, which is apparently a carbonyl-amino reaction, was investigated 80° and 100° C.

Starch

Formation of starch in wheat grain.

WHISTLER, R. L. AND YOUNG, J. R. (Purdue Univ., Lafayette, Ind.). *Cereal Chem. 37*, 204–11 (1960).

Wheat plants were either injected with randomly labeled sucrose-C^{14} or allowed to take up radioactive carbon dioxide in the light. In both groups of plants, the amylose became labeled much sooner than the amylopectin, clearly indicating that the path to amylose is more direct than the path of amylopectin. Although no evidence is available to suggest that amylose is not converted to amylopectin while these polysaccharides are being formed, the data suggest that amylose is not extensively converted to amylopectin once it has become incorporated into the granule.

ORGANIC CHEMISTRY

Peptide studies. III. An antibacterial tripeptide of L- and D-valine.

SHANKMAN, S., HIGA, S. AND GOLD, V. (Pasadena Foundation for Med. Re-

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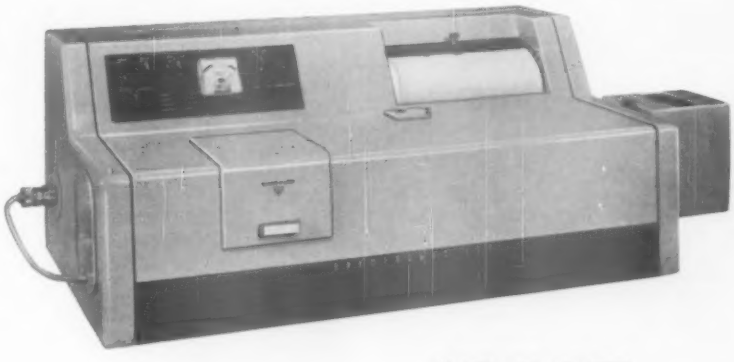

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search, Calif.). *J. Am. Chem. Soc. 82*, 990–1 (1960).

The tripeptide L-valyl-L-valyl-D-valine is shown to be antibacterial at 0.05 mg. per ml. for 3 cultures. The other peptides or derivs. were not antibacterial at 20 times this concn.

RADIOCHEMICAL TECHNOLOGY

Changes in the radiation sensitivity of some enzymes and the possibility of protection against the direct action of ionizing particles.

BRAAMS, R. (Yale Univ., New Haven, Conn.). *Radiation Research 12*, 113–19 (1960).

The variation of the sensitivity for inactivation by ionizing radiation of vacuum-dried invertase was investigated. It was found that different purification methods lead to different radiation sensitivities. In some prepns. the addn. of cysteine, glutathione, or yeast ext. can lead to a reduced sensitivity. A possible mechanism for this effect is discussed.

PERSONNEL

Dr. Jean F. Caul, senior project leader in the Food and Flavor Department of Arthur D. Little, Inc. in Cambridge, Massachusetts, is in residence at West Germany's Justus Liebig University of Giessen to introduce a new method of analyzing flavors and odors at its Institut für Ernährungswissenschaft (Institution for Nutritional Research).

Jean F. Caul

Dr. Caul is teaching the concept and principles of the "flavor profile" method of analysis developed by Arthur D. Little, Inc., an international industrial research company. The project will be jointly financed by ADL and the University.

The American Society of Enology has announced that the late **John G. B. Castor** is to be honored by a $750 annual scholarship, to be known as the John G. B. Castor Memorial Scholarship. Dr. Castor was Professor of Enology at the University of California at Davis.

The scholarship will be awarded to anyone who is a citizen of the United States and pursues a course of study in the sciences basic to the wine industry in any college or university in the United States. Those interested in this scholarship should contact the secretary of the Society, Lewis A. Stern, P. O. Box 1173, Modesto, California.

John W. Zahradnik, Associate Professor of Agricultural Engineering at the University of Massachusetts, has been awarded a Danforth Fellowship by the Danforth Foundation. The fellowship covers a twelve month period starting in September 1960. He has been granted a leave of absence from the University, where he has served since 1954, to do advanced study toward a doctorate. He plans to study at the Massachusetts Institute of Technology in the department of Food Technology.

J. W. Zahradnik

IN MEMORIAM

It is with deep sorrow that we record the death of George Garnatz, director of the Kroger Food Foundation, Cincinnati, Ohio, and a former president of the Institute of Food Technologists. His death occurred suddenly on May 18, 1960, in San Francisco, where he had been in attendance at the Twentieth Annual Meeting of IFT.

Born in Cincinnati, Ohio, George Garnatz was educated in that city, receiving a degree in chemical engineering from the University of Cincinnati in 1921. Immediately on graduation he was employed by the Kroger Company and assigned the task of establishing a baking laboratory. This laboratory quickly won recognition in the cereal and baked products field. It was incorporated into the Kroger Food Foundation upon the founding of that institution. In August, 1945, Mr. Garnatz became director of this widely known and productive research organization.

The career of George Garnatz was conducted entirely in the field of food research and development but his interests in food science were versatile, including engineering, baking technology, cereal chemistry and the sensory testing of food. In the latter area he had an abiding interest, considering sensory evaluation of foods a major tool for flavor research and quality control. He also directed surveys of consumer preference and worked diligently to increase the accuracy of survey methods. In the broader aspects of food technology, his participation in movements to promote national awareness of the importance of food research was especially noteworthy. The Institute of Food Technologists and all who are engaged in the study of food are greatly indebted to him for his tireless efforts to bring status and prestige to the profession during its formative years.

The breadth of George Garnatz' professional activities is evidenced by his active participation in many professional societies. He was president of the American Association of Cereal Chemists in 1939, a charter member and, as mentioned, president of IFT in 1956–57, a fellow of the American Institute of Chemists, and a former chairman of the Baking Industry Research Advisory Council. His other memberships included the American Chemical Society, Association for the Advancement of Science, Society of the Chemical Industry, and the American Society of Baking Engineers. In 1953 he was selected "Engineer of the Year" by Technical and Scientific Societies of Cincinnati.

He is survived by his wife, Mrs. Edna Garnatz, and a daughter Mrs. Thomas Grooms, both of Cincinnati, and his mother and two sisters, residing in Oakland, California.

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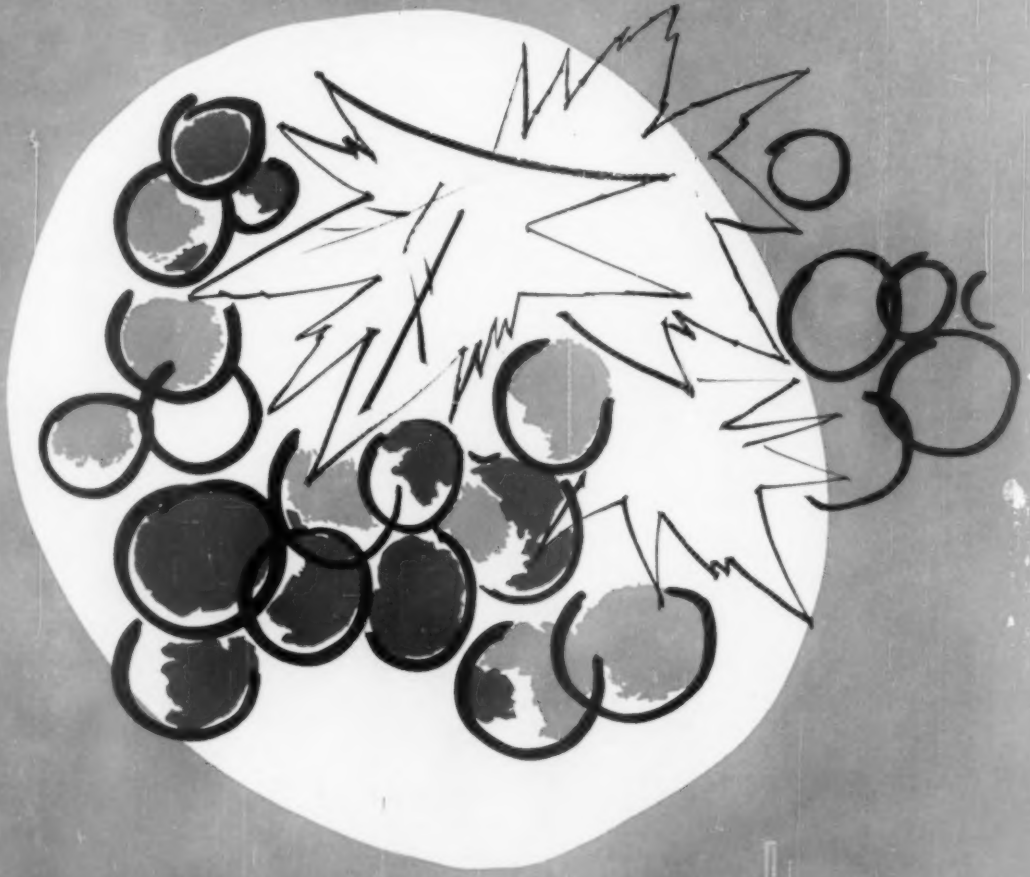

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